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Performance of the Chinook Salmon Enhancement Program in Willow Creek, Alaska, 1985-1991

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ABSTRACT

The contribution of hatchery produced chinook salmon *Oncorhynchus tshawytscha* to the Willow Creek sport harvest and escapement in 1991 was assessed using a roving creel survey at three sites on Willow Creek, a weir at Deception Creek (a tributary to Willow Creek), aerial peak spawning escapement surveys, and post spawning carcass surveys. Anglers expended 38,283 angler-hours to harvest and catch 3,300 and 4,826 chinook salmon, respectively. The majority of the effort (93%) occurred at the "mouth" fishery. During the mouth fishery, 10,461 angler-days were expended in 1991. This is an increase of over 5,000 angler-days since 1988, when hatchery fish were first recorded in the harvest. The hatchery contribution to the mouth fishery sport harvest from chinook salmon smolt stocked in the Willow Creek drainage was 26.3%, less than the 1989-1990 contributions of 37.8% and 36.4%. Escapement index counts and weir counts indicated a minimum of 2,753 spawners in Willow and Deception creeks combined. Carcass surveys in the mainstem of Willow Creek revealed no hatchery contribution to the spawning escapement. Carcass surveys in Deception Creek indicated a relative hatchery contribution of 31% to the spawning escapement. The total smolt release for 1991 was approximately 391,700.

Historical age, sex, and size data were compiled and summarized to establish a baseline for comparison. Data collected from hatchery returns thus far are insufficient to determine the performance of the Willow Creek chinook salmon stocking program as measured through attainment of program goals and objectives.

KEY WORDS: chinook salmon, *Oncorhynchus tshawytscha*, Willow Creek, Deception Creek, fish culture, smolt, stocking, creel survey, sport effort, sport catch, sport harvest, escapement counts, population, hatchery contribution, age, sex, length.

INTRODUCTION

The sport fishery for chinook salmon *Oncorhynchus tshawytscha* in the Northern Cook Inlet (NCI) area was closed periodically during the 1960s and 1970s because of small returns. Increases in the returns of chinook salmon to NCI drainages allowed reopening of a limited sport fishery in 1979. An intensively managed and growing fishery has existed since that time (Figure 1).

Willow Creek, a tributary of the Susitna River (Figure 2), was designated as a potential recipient for chinook salmon enhancement in the Cook Inlet Regional Salmon Enhancement Plan (CIRPT 1981). Development of a chinook salmon enhancement program at Willow Creek was spurred by construction of a road to the mouth of Willow Creek and establishment of the Willow Creek Recreation Area in the mid 1980s. A chinook salmon smolt stocking program was initiated at Willow Creek in 1985. With the exception of 1987, this stocking program has continued annually. An on-site creel survey has been conducted since 1979 to aid inseason management of the fishery. The creel survey was redesigned in 1988 to monitor success of the enhancement program.

Willow Creek has developed into the most heavily utilized road accessible sport fishery for chinook salmon in NCI (Mills 1980-1991). The primary purpose of the Willow Creek enhancement program is to increase chinook salmon fishing opportunities on a sustainable basis by supplementing the existing natural run with hatchery fish. Natural chinook salmon production is relatively stable and appears near maximum. Present exploitation of this production also appears to be approaching maximum. Therefore, chinook salmon abundance must be increased if the fishery is to provide significant additional fishing opportunities.

The primary goals of the Willow Creek chinook salmon enhancement program are to:

1. maintain the present quality and quantity of natural chinook salmon production;
2. produce through supplemental hatchery production an additional 6,000 returning chinook salmon of which 4,000 would be available for harvest at Willow Creek on an annual basis by 1994; and
3. provide an additional 10,000 angler-days of chinook salmon fishing opportunity annually at Willow Creek during weekdays by 1994.

To help measure program performance and achieve project goals, the following objectives were identified:

1. ensure that approximately 4,500 chinook salmon spawn naturally at Willow Creek each year;
2. annually stock 200,000 chinook salmon smolt into Willow Creek in order to yield 6,000 returning adults at 3%[1] survival;

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[1] A marine survival rate of 3% was used in planning this project. This assumed survival rate will be maintained until the project evaluation is completed in 1994.

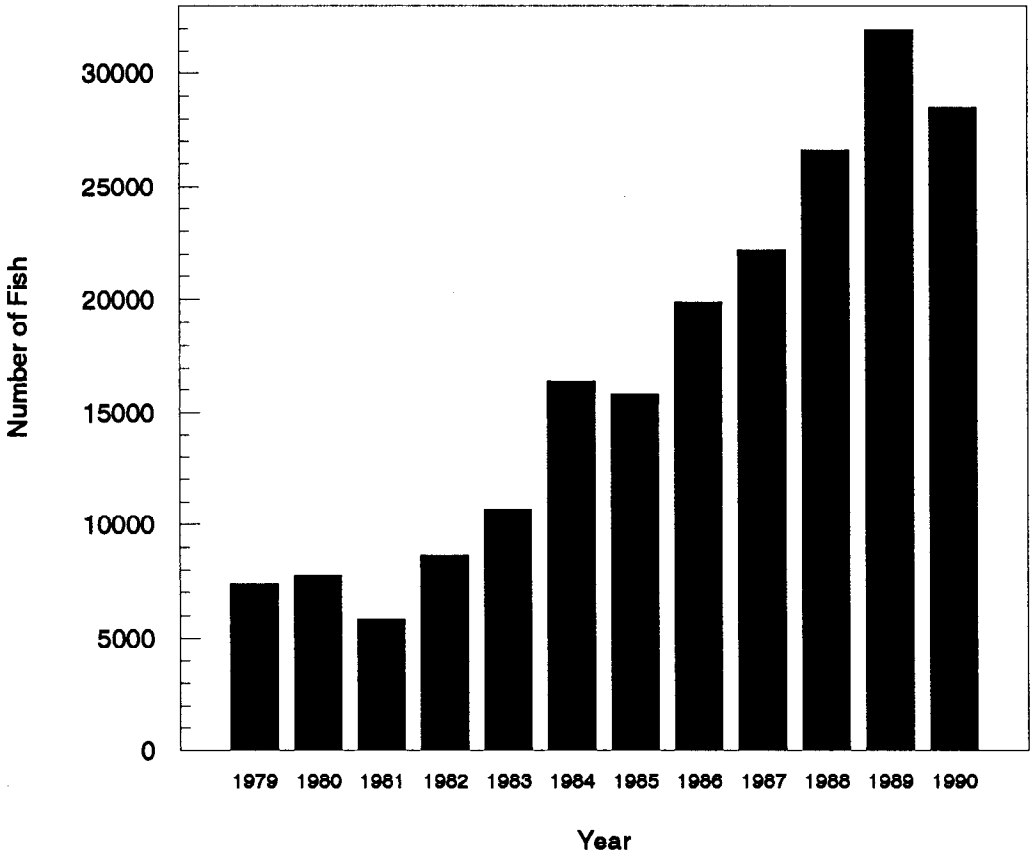

Figure 1. Yearly chinook salmon sport fish harvest in Northern Cook Inlet, 1979-1990. Data reported in Mills (1980-1991).

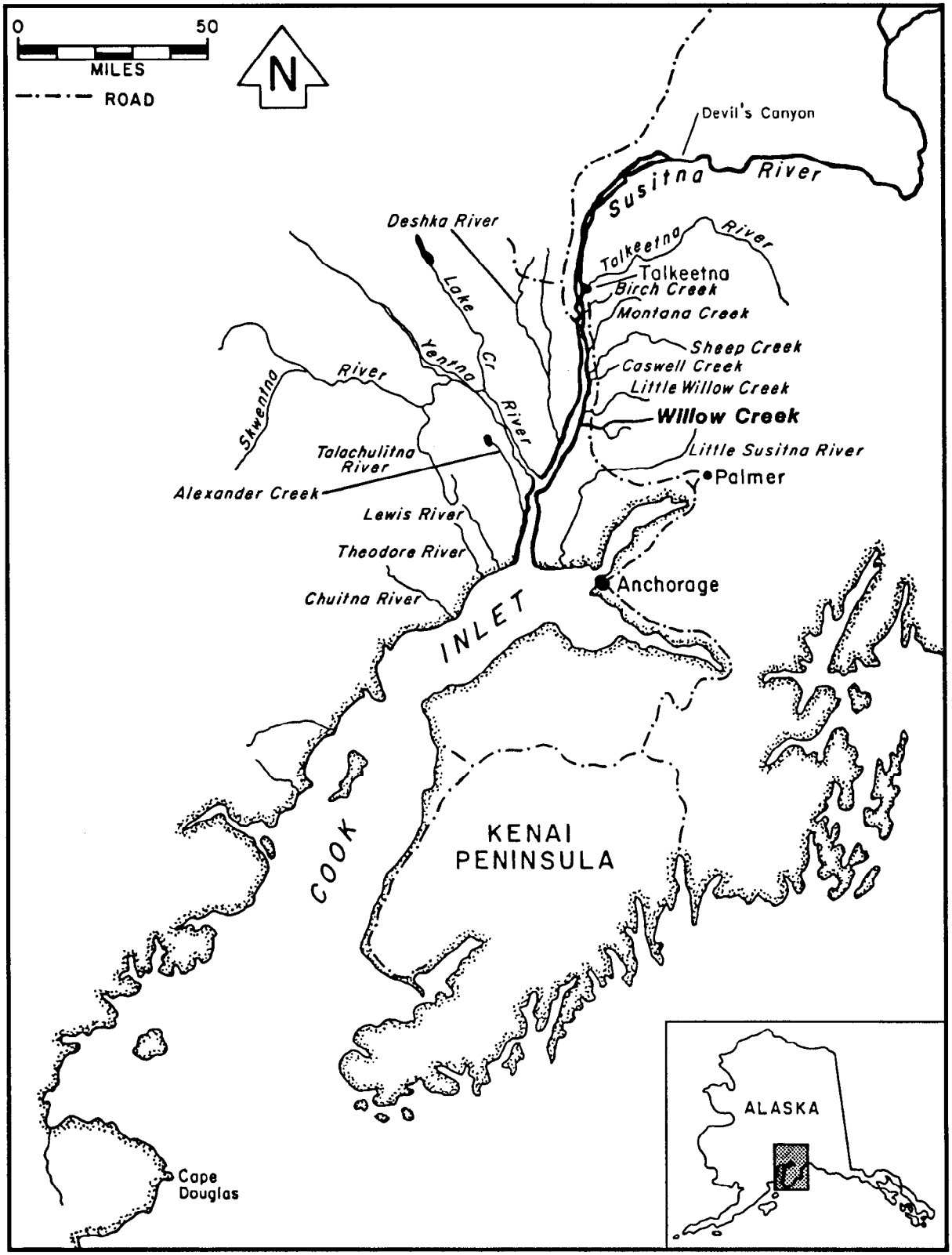

Figure 2. Map of Northern Cook Inlet and the Susitna River drainage.

3. ensure that the historical age and sex compositions are not significantly altered by supplemental production; and
4. provide weekday fishing opportunity for chinook salmon at Willow Creek during June in order to provide 10,000 additional angler-days of participation.

This report presents fish culture, creel survey, escapement, age, sex, length, and hatchery contribution data collected from the Willow Creek program in 1991. Additionally, a compilation of all historic data used to evaluate this enhancement program is presented. Program success is evaluated by comparing historic performance to achievement of stated program goals and objectives. Finally, recommendations for consideration in future program planning are developed.

METHODS

Fish Culture

Chinook salmon smolt were released at two separate locations in the Willow Creek drainage (Figure 3) in 1991. Smolt were released at the Deception Creek bridge (the primary stocking site in the past) on the Hatcher Pass Road and at an additional site in a side slough off the mainstem Willow Creek below the Parks Highway. Approximately 20% of the smolt were adipose clipped and coded wire tagged following standard hatchery methodology (ADF&G 1983).

A dual weir was installed on Deception Creek on 9 July to capture brood stock for the 1991 egg take (Figure 3). All fish entering the weir complex were detained between the weirs until the egg take was complete. The Deception Creek egg take took place on 23 and 26 July. On those dates, fish between the weirs were seined and checked for ripeness. Ripe fish were killed and placed on a clean tarp. Milt from three males and eggs from three females were combined in a 5 gallon bucket. Water from Deception Creek was added to the bucket to initiate fertilization. After a 1 minute waiting period, excess milt, coagulated blood, and other debris were rinsed from the fertilized eggs. The clean eggs were put into plastic bags and placed in coolers for 45 to 90 minutes to water harden. The water hardened eggs were packed in ice to keep cool during shipment to Fort Richardson hatchery where they were incubated.

Creel Survey Design

A roving creel survey (Neuhold and Lu 1957) was conducted to obtain estimates of angler effort, catch, and harvest of chinook salmon in the Willow Creek sport fishery. The fishery was sampled using a stratified, three-stage, roving survey design.

Willow Creek was open to fishing for chinook salmon in all waters within a 0.4 km (0.25 mi) radius of the creek's confluence with the Susitna River and upstream to the Parks Highway. This section was open daily to fishing from 1 January to 17 June. After 17 June, Willow Creek was to open by regulation only during the 3-day periods of 0001 hours each Saturday to 2400 hours on Monday, commencing on 22 June and ending on 1 July. By emergency order, Willow Creek, from the mouth to one quarter mile upstream, remained open on

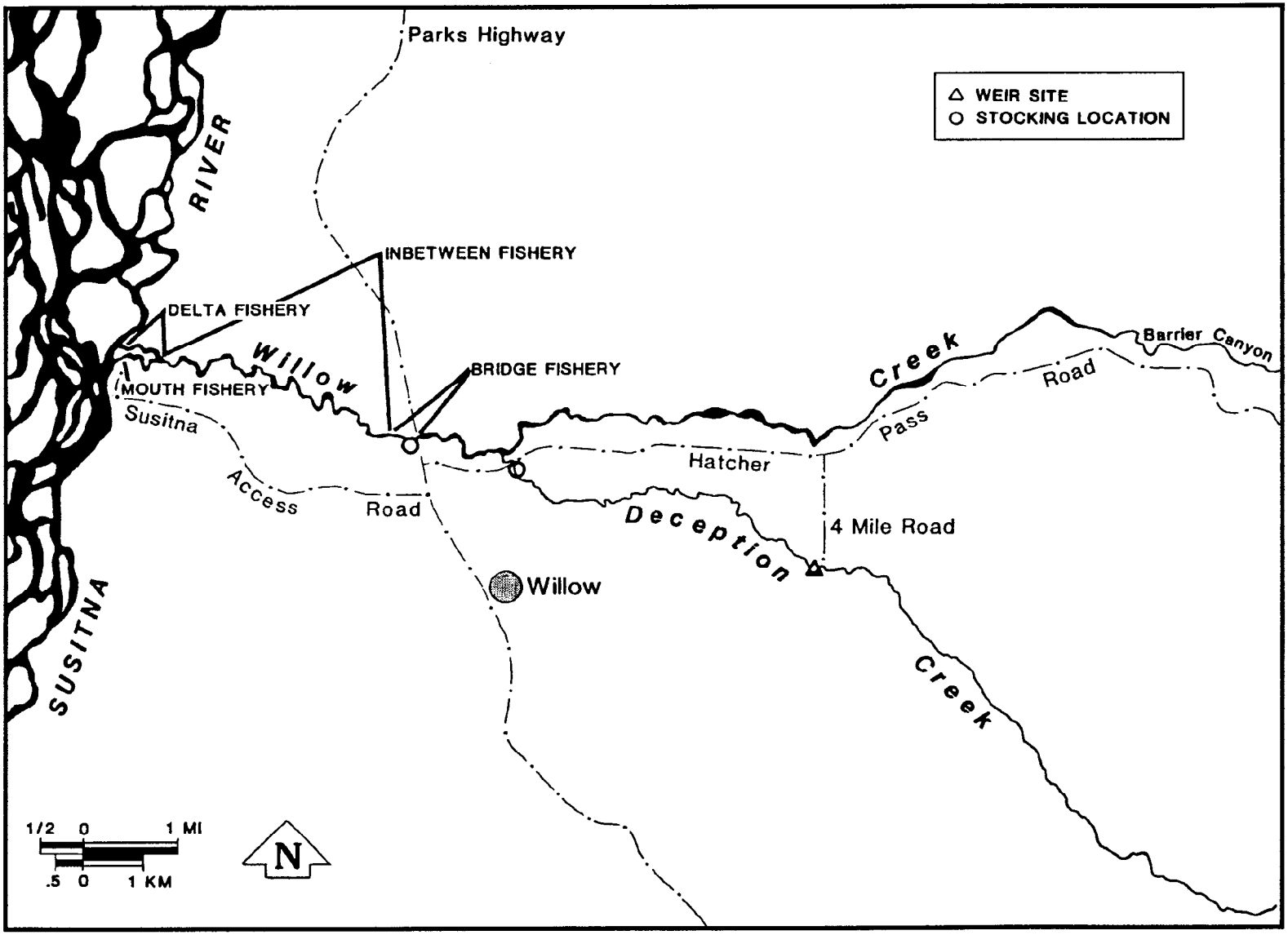

Figure 3. Map of Willow and Deception creeks showing the location of creel survey areas, carcass survey areas, smolt stocking sites, and egg-take sites.

6 and 7 July. Additional fishing time was to be offered if strong hatchery returns were detected.

Willow Creek is accessible by road and primary access to the fishery is by vehicle and foot. The majority of anglers fished within 0.8 km (0.5 mi) of the Parks Highway bridge and at the mouth. Relatively few anglers accessed the fishery through other locations. Four locations were surveyed in 1991 (Figure 3):

1. the head of the trail that leads to the mouth of Willow Creek, where anglers reach the stream by foot and fish in the vicinity of the creek's confluence with the Susitna River (mouth fishery);

2. the delta area of the mouth accessible only by boat (delta fishery);

3. the midriver reach of the creek between the area accessed through the mouth survey and the area fished at the Parks Highway bridge (inbetween fishery); and

4. the Parks Highway bridge, where anglers either access the creek from the road and fish near the bridge or use the private boat launch near the bridge (bridge fishery).

During all strata, for each of the above survey locations, days were sampled at random without replacement (WOR), and represented the first sampling stage in our stratified three-stage sample survey. Within each day sampled, sample periods were selected at random WOR from the available periods, and represented the second stage units. Within each selected sample period, three random-systematically chosen angler counts were conducted and represented the third sampling stage for the angler count data. For the angler interview data, the anglers interviewed represented the third stage of catch per unit effort (CPUE) or harvest per unit effort (HPUE) information. The delta area section of the fishery was surveyed to estimate angler effort by boat anglers who were not surveyed by the mouth component of the survey. Therefore, only angler counts were conducted on the delta area component of survey. Strata definitions and sampling parameters for each survey location are listed in Appendix A1.

Creel Survey Data Collection

The following effort, catch, and harvest information were collected from each completed-trip angler interviewed exiting at the mouth and Parks Highway surveys (incompleted-trip anglers were not interviewed) and all anglers (completed-trip and incompleted-trip) fishing the midriver section: number of hours fished, number of fish over 16 inches in length harvested (kept) and number of fish over 16 inches in length released, by species, whether the angler was guided or unguided, and whether the angler used a boat in his/her fishing effort.

Survey technicians monitored the mouth fishery at the head of the trail leading from the parking lot to the fishing area at the mouth of the creek. Time not spent conducting angler counts was spent interviewing exiting anglers, inspecting the observed harvest for adipose clips, and collecting biological data.

Survey technicians conducted angler counts by boat in the delta area of the mouth (Figure 3). Counts did not include anglers fishing from shore counted by survey technicians at the mouth. No interviews were conducted and no biological data were collected.

The midriver section of the fishery survey was done by boat launched at the Parks Highway bridge. Survey technicians surveyed the portion of the creek downstream of the area accessed by foot from the Parks Highway bridge to the area accessed from the parking area at the mouth. Time not spent conducting angler counts was spent interviewing anglers, inspecting the observed harvest for adipose clips, and collecting biological data.

The Parks Highway fishery was monitored by creel survey technicians stationed at the Parks Highway bridge area. Interviews were conducted with shore anglers fishing on either side of the creek and boat anglers exiting at the boat launches. Data from anglers who fished the midriver portion but were interviewed while exiting through the Parks Highway survey site were combined with the midriver data. Time not spent conducting angler counts was spent conducting interviews, inspecting the observed harvest for missing adipose fins and collecting biological data.

Creel Survey Data Analysis

Angler Effort, Catch, and Harvest:

Procedures used to estimate angler effort for and the catch and harvest of chinook salmon in the mouth, midriver, and Parks Highway sections of the 1991 Willow Creek creel survey were the same as those used in the 1990 Little Susitna coho salmon shore angler creel survey. The procedures are outlined in equations 27 through 44 in Bartlett and Bingham (1991), and represent a 3-stage roving estimation approach. This approach involved using a systematic-random estimator to estimate angler effort on a sample by sample basis. Catch and harvest estimates for each sample were obtained by a ratio estimator: by combining the estimated effort (for the sample) with estimates of CPUE and HPUE obtained from the angler interviews. The CPUE and HPUE estimates were obtained by the jackknife estimation approach (Efron 1982). The jackknife approach for estimating CPUE and HPUE was used since most other estimators are known to be biased (for use as ratio estimators, i.e., for expansion), and the jackknife estimate has been shown to be less biased and procedures exist for correcting some of this bias (see Cochran 1977, section 6.15, pages 174-177; and Smith 1980).

Catch Per Unit of Effort:

The CPUE of anglers fishing for chinook salmon in Willow Creek sport fishery surveyed during 1991 was estimated by the procedures noted below. The anglers were treated as individual units in a test fishery operating under the traditional linear model:

$$[c/e]_i = q\,N + \epsilon_i$$

where: c/e is the catch per unit of effort during the *ith* angler-trip; N is abundance (of the fish); q is the catchability coefficient; and ϵ is random error with mean = 0 and variance = σ^2.

Hence the estimates of CPUE were obtained from unweighted means for each section of the fishery during each time period stratum[2] as detailed in Appendix A2. The estimates obtained by these procedures were indicative of the abundance of chinook salmon as they passed through the fishery.

Distribution of Angler Catches and Harvests:

The distribution of angler catches and harvests was used as a measure of angler success and was estimated as described in the following text. The "distribution of catches and harvests" was defined as the fraction p_k of angler-trips in which "k" or more fish were caught and "k" was expressed as $k = 1$ to k_{max}. Additionally, we defined p_k to be the proportion of angler-trips that resulted in the catch or harvest of zero chinook salmon for $k = 0$. If $k_{max} = 5$, then one set of data was analyzed 6 times to obtain all possible fractions p_k in a set. There were two sets of p_k's, one set for both catch and harvest. Besides the k_{max} iterations, there was stratification. For each iteration from 0 to k_{max}, there were calculations for each stratum in the fishery.

As an example, begin with the fraction of angler-trips in which one or more chinook salmon were caught. The first step was to code the data prior to calculation. The coding was necessary because not all sampling periods (days) were the same "size": more anglers fished during some periods than others. Ignoring these differences in size would have promoted bias in estimates of angler success when statistics were averaged across sampling periods within a stratum. The coding adjusted for this possible discrepancy (Sukhatme et al. 1984). After coding, standard three-stage estimation procedures (Cochran 1977) were used to estimate the various proportions, their variances and standard errors, as outlined in detail in Appendix A3.

Assumptions:

The assumptions necessary for unbiased point and variance estimates of angler effort, catch, harvest, CPUE as an index of abundance, catch and harvest distribution, and proportion of harvest by bag size, obtained by the procedures outlined above, included the following:

1. anglers interviewed at each section of the fishery were representative of the total angler population;

2. anglers accurately reported their hours of fishing effort, the number of fish caught, and the number of fish released;

3. catch and harvest rates were independent of duration of fishing trip (as per DiCostanzo 1956); and

4. the angler count process was approximately instantaneous, or we assumed that the survey technician traveled substantially faster than anglers move about or exit or enter the fishery; and

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[2] Assuming that abundance and hence catch rates will vary among areas in the fishery and among seasonal periods, but will not be expected to change appreciably among sampling stages.

5. no significant fishing effort occurred during the hours not surveyed.

The above assumptions were most likely valid with the exception of assumption 2. Not all anglers were able to remember the hours of fishing effort and tend to report a number of hours between the length of the trip and the actual number of hours spent fishing on the trip. For unbiased estimates of CPUE as an index of abundance, we assumed that the catchability coefficient (q) did not change in a manner that negated the use of CPUE as an index of abundance and that "good" (or for that matter "poor") anglers were not selectively fishing during certain periods or areas of the fishery. However, catch rates may be more reflective of good anglers (higher catchability coefficients) rather than higher abundance (and visa versa for poor anglers).

Escapement Surveys

Chinook salmon spawning in Willow Creek and Deception Creek were counted by aerial survey (rotary-wing aircraft), foot survey, and at a weir placed across Deception Creek. Escapement surveys were conducted during the peak spawning period which was identified through frequent inspections of spawning activity. Escapement data reported were the number of fish, both alive and dead, observed during a single survey.

Raw survey counts of chinook salmon in Willow Creek were not expanded to account for streamlife, poor visibility, or missed fish. The actual number of chinook salmon observed was considered the escapement index and was considered to be a minimum escapement estimate. These records were archived in the area office stream files.

Size, Sex, and Age Compositions

Chinook salmon harvested by the sport fishery at each sampling location were sampled for age, length, and sex information.

Carcasses of post-spawn chinook salmon in Willow Creek from the canyon downstream to the Parks Highway bridge were also sampled (Figure 3). Length, sex information, and scales were collected from every fish possible. However, during carcass surveys, some fish were badly decomposed which precluded scale collection and accurate measuring.

Sampled fish were measured from the middle of the eye to fork of the tail, to the nearest 5 mm. The sex of those fish selected for age composition was recorded. Three scales were collected on the left side of each fish approximately two rows above the lateral line and on the diagonal row downward from the posterior insertion of the dorsal fin as described in Clutter and Whitesel (1956). Scales were mounted on adhesive-coated cards and thermohydraulic impressions were made in cellulose acetate. Age determinations were made by examination of scale impressions using a microfiche reader. Ages were designated using the European method (Koo 1962). Age, sex, and length data were recorded on standard biological mark-sense forms.

Examination of scales from 1989 and 1990 indicated that freshwater growth in scales from hatchery-produced fish was indistinguishable from that in wild

fish when viewed on a microfiche reader (Sweet and Webster 1990; Sweet et al. 1991). Therefore, hatchery-produced and wild fish were combined in all age classes.

Estimates of age composition (proportion) for the subsampled chinook salmon were calculated for each stratum for the creel survey and the carcass surveys. Estimates of proportion of fish harvested by sex and age class across all strata were obtained by a weighted means procedure. Complete details of the estimation procedure are presented in Appendix A4.

Estimates of mean length by age group of chinook salmon subsampled from the sampled harvest were calculated by the procedures outlined in Sokal and Rohlf (1981, Boxes 4.2 and 7.1, pages 56 and 139). We assumed that length at age did not vary substantially from stage to stage or stratum to stratum and treated our samples of fish lengths as if collected by a simple random sampling program.

Contribution of Coded Wire Tagged Stocks

In addition to the age, sex, and length information, chinook salmon harvested at Willow Creek were examined for a missing adipose fin (indicating the presence of a coded wire tag or CWT). Daily records were kept of both the numbers of fish examined for a missing adipose fin as well as the number of fish observed to have a missing adipose fin. Heads were collected from the fish with a missing adipose fin and sent to the Fisheries Rehabilitation, Enhancement, and Development (FRED) Division laboratory for decoding. Carcasses from the chinook salmon escapement in the reaches of Willow Creek and Deception Creek upstream of the Parks Highway bridge were also inspected for adipose finclips to recover associated coded wire tags and estimate hatchery contributions.

Contributions of coded wire tagged stocks to the sport harvest, with associated variances and standard errors for each release group, were estimated using the approach outlined by Clark and Bernard (1987) as modified by Conrad and Larson (1987) (Appendix A5). We did not have an absolute measure of the escapement, therefore, hatchery contributions for the escapement could not be estimated in numbers. Accordingly, we estimated the relative contribution (Appendix A5).

Data collected included number of carcasses observed, number of fish inspected for adipose finclips, number of clips observed, mid-eye to fork length, and scale collection. Heads from fish with a missing adipose fin were collected and decoded as described above. Adult chinook salmon were expected to return to Willow Creek from the stocking of smolt in 1986, 1988, 1989, and 1990 (Appendix B1). There was also the possibility of a return from 1988 and 1989 Montana Creek and Sheep Creek smolt releases (Appendix B2) (Chlupach 1990).

Hatchery contribution estimates were not made for commercial fishery interceptions or other nontarget fisheries where interception was believed to occur and no recovery information existed. In addition, no estimates were made for incidental tag recoveries which occurred outside the scope of this program.

RESULTS

Fish Culture

An estimated 391,669 chinook salmon smolt were stocked on four separate dates between the two stocking locations (Appendix B1). Approximately 20% of the release was to have been coded wire tagged. However, a check of tag retention prior to release revealed a relatively poor tag retention of 73.8%. Consequently, only 15.9% of the release contained valid coded wire tags.

A total of 107 fish were utilized for brood stock to obtain an estimated 430,000 chinook salmon eggs. Based on coded wire tag recovery from fish utilized for brood stock, an estimated 63% (SE = 22%) were from hatchery origin. Approximately half of these eggs will be used to produce smolt for the 1992 Willow Creek stocking. The remainder will be used for other stocking projects.

Creel Statistics

The total estimated angler effort for all survey sites was 38,283 (SE = 1,210) angler-hours (Table 1) of which 35,566 (SE = 1,194) angler-hours (93%) were at the mouth, 902 (SE = 111) angler-hours (2%) were at the Parks Highway bridge, and 1,815 (SE = 164) angler-hours (5%) were expended by anglers in the midriver fishery.

The total estimated harvest and catch of chinook salmon in Willow Creek for all sites combined was 3,300 (SE = 243) and 4,826 (SE = 336) fish, respectively (Table 1). The estimated harvest at the mouth was 2,997 (SE = 240) contributing 91% of the total. The estimated harvest at the highway was 130 (SE = 36) contributing 4% and the estimated midriver harvest was 173 (SE = 21) contributing 5%. The estimated catch at the mouth was 4,488 (SE = 332) 93% of the total, at the highway 132 (SE = 36) 3% of the total and midriver 206 (SE = 32) 4% of the total. During the Willow Creek fishery, 32% of the chinook salmon caught by anglers were released.

The delta mouth angler counts ranged from 1 to 20. The total estimated effort for the period of 15 through 17 June was 412 (SE = 104) angler-hours.

Catch rates for the Willow Creek mouth fishery varied from 0.03 fish per angler-hour for the period of 6 and 7 July (strata VII) to 0.29 for the period of 29 June through 1 July (strata V). The mean catch rate for the entire season was 0.19 fish per angler-hour (Table 1).

Twenty-nine percent (SE = 1.8%) of the Willow Creek mouth angler-trips were successful, resulting in one or more fish harvested. Less than 1% (SE = 0.1%) resulted in a two fish harvest, and the remaining 71% (SE = 3.5%) failed to harvest a fish (Appendix C1).

Escapement Statistics

Escapement counts in Willow Creek and Deception Creek, a tributary to Willow Creek, were 2,006 and 747 chinook salmon, respectively. During carcass surveys from Willow Creek canyon to the confluence of Deception Creek, 414 chinook carcasses were observed, 270 were examined and no adipose clips were

Table 1. Estimated catch rate, effort, catch, and harvest by strata for the Willow Creek chinook salmon fishery creel survey in 1991.

Strata	Date	CPUE (catch per angler-hour)	SE	Effort in angler-hours	SE	Catch[a]	SE	Harvest[a]	SE
Mouth									
1	6/8-14	0.07	0.02	4,908	536	242	54	151	40
2	6/15-17	0.13	0.02	4,210	180	296	26	252	25
3	6/18-21					fishery closed			
4	6/22-24	0.25	0.02	10,278	489	1,699	159	1,100	103
5	6/29-7/1	0.29	0.02	11,668	813	2,132	285	1,428	210
6	7/2-5					fishery closed			
7	7/6-7	0.03	0.01	4,502	454	119	24	66	19
Total		0.19	0.01	35,566	1,194	4,488	332	2,997	240
Between Highway and Mouth									
1	6/8-14					no survey			
2	6/15-17					no survey			
3	6/18-21					fishery closed			
4	6/22-24			348	66	0	0	0	0
5	6/29-7/1			1,467	150	206	32	173	21
6	7/2-5					fishery closed			
7	7/6-7					fishery closed			
Total				1,815	164	206	32	173	21
Highway									
1	6/8-14					no survey			
2	6/15-17					no survey			
3	6/18-21					fishery closed			
4	6/22-24					no survey			
5	6/29-7/1			902	111	132	36	130	36
6	7/2-5					fishery closed			
7	7/6-7					fishery closed			
Total				902	111	132	36	130	36
All Sites Combined									
1	6/8-14			4,908	536	242	2,926	151	1,613
2	6/15-17			4,210	180	296	692	252	612
3	6/18-21					fishery closed			
4	6/22-24			10,626	494	1,699	159	1,100	103
5	6/29-7/1			14,037	834	2,470	352	1,731	268
6	7/2-5					fishery closed			
7	7/6-7			4,502	454	119	24	66	19
TOTAL				38,283	1,210	4,826	336	3,300	243

[a] Only includes chinook salmon over 16 inches.

recorded. Carcass surveys from the confluence of Deception Creek to the Parks Highway bridge resulted in 22 carcasses observed, all of which were examined and one adipose clip was observed. Carcass surveys from the mouth of Deception Creek upstream to the ADF&G weir resulted in 190 carcasses observed, 162 examined and six adipose clips observed (Table 2).

Size, Sex, and Age Compositions

Three hundred fifty-one chinook salmon were sampled from the sport harvest at the mouth fishery for age, length, and sex. Age class 1.4 dominated the harvest at 50%, age 1.3 contributed 36%, and age 1.2 contributed 9%. The harvest consisted of 51% males and 49% females (Table 3). Mean lengths ranged from 1,000 mm for age 1.5 fish to 362 mm for age 1.1 fish (Table 4).

Twenty-eight percent of the mouth fishery harvest consisted of hatchery-produced fish whose ages were 0.2 or 0.3. Scales from hatchery-produced fish were indistinguishable from wild fish scales. Therefore, both are included in age groups 1.2 and 1.3.

Forty-nine chinook salmon were sampled from the highway and midriver fisheries sport harvest for age, length, and sex. Age class 1.4 dominated the harvest at 53%, age 1.3 contributed 39%, and age 1.2 contributed 6%. The harvest consisted of 82% males and 18% females (Table 3). Mean lengths ranged from 1,009 mm for age 1.4 fish to 370 mm for age 1.1 fish (Table 4).

One hundred seventy-seven readable scales were collected during carcass surveys on Willow Creek from the canyon to the confluence of Deception Creek. Age class 1.4 dominated with 66% of the sample, age 1.3 contributed 22%, age 1.2 contributed 7%. Age classes 1.1, 1.5, and 2.4 contributed the remaining 5%. Of the carcasses surveyed, 43.5% were male and 56.5% were female (Table 3). Mean lengths ranged from 987 mm for age 1.5 fish to 350 mm for age 1.1 fish (Table 4).

Contribution of Coded Wire Tagged Stocks

Of the estimated sport harvest of 2,997 chinook salmon at the mouth of Willow Creek, 1,063 were examined and 28 were observed to have a missing adipose fin and a decodable coded wire tag (2.6% of the sample). These 28 fish represented two Willow Creek releases (1988 and 1989), and one Montana Creek release (1988) (Appendix C2). The estimated contribution to the harvest of hatchery-produced chinook salmon at the Willow Creek mouth fishery originating from fish released in Willow Creek was 787 fish (SE = 158) or 26.3% (Table 5). There was an additional contribution of 59 (SE = 34) hatchery-produced fish, 2.0%, from the 1988 Montana Creek release. The total hatchery contribution was 28.3%. The timing of the harvest of hatchery fish coincides with that of wild fish (Figure 4).

An estimated 303 chinook salmon were harvested from the Willow Creek highway bridge and midriver fisheries. Eighty-eight were examined and none were observed to have a missing adipose fin (Appendix C2). The contribution of hatchery-produced fish to this portion of the fishery was estimated at zero. It is reasonable to assume that hatchery fish were harvested but not detected because of the small sample size.

Table 2. Coded wire tag recoveries from Willow and Deception Creek carcass surveys and Deception Creek weir egg collection in 1991.

Location	Date	Live Fish	Carcasses Observed	Carcasses Examined	Adipose Clips	Heads Collected	Scales Collected	Coded wire tag number
Willow Ck. canyon downstream to Deception Ck. confluence	8/01	389	107	79	0	0	63	----
	8/06	103	168	96	0	0	96	----
	8/09	61	139	95	0	0	95	----
	Sub-Total	553	414	270	0	0	254	
Willow Ck. at Deception Ck. confluence to Parks Highway bridge	8/09	5	22	22	1	1	0	31-17-58
Willow Creek Total		558	436	292	1	1	254	
Deception Ck. above ADF&G weir	7/29,30	209	18	18	0	0	0	----
	8/05	96	6	6	0	0	0	----
	8/12	13	19	16	0	0	0	----
	Sub-Total	318	43	40	0	0	0	
Deception Ck. weir to mouth	7/29,30	416	56	47	1	1	0	31-17-58
	8/05	202	86	77	2	2	0	31-17-58, 31-17-59
	8/12	35	48	38	3	3	0	31-17-58, 2 without tags
	Sub-Total	653	190	162	6	6	0	
	Total	971	233	202	6	6	0	
Deception Ck. weir egg take	7/23		54	54	3	3	0	31-17-58 = two tags one head without tag
	7/26		53	53	6	6	0	31-17-58 = five tags one head without tag
	Sub-Total		107	107	9	9	0	
Deception Creek Total		971	340	309	15	15	0	

Table 3. Sex and age composition of chinook salmon sampled from the Willow Creek sport fishery and carcass surveys in 1991.

Fishery	Sex		Age Group 1.1	1.2	1.3	1.4	1.5	2.2	2.3	2.4	Total
Mouth[a]											
	Male	Percent	3.7	9.4	22.1	16.0	0.0	0.0	0.0	0.0	51.0
	Female	Percent	0.0	0.0	13.7	34.9	0.3	0.0	0.0	0.1	49.0
	Combined	Percent	3.7	9.4	35.8	50.1	0.3	0.0	0.0	0.1	100.0
	(n = 351)[b]	SE (%)	0.9	1.4	3.1	3.9	0.3	0.0	0.0	0.1	
Parks Highway Bridge and Mid River											
	Male	Percent	2.0	6.1	32.7	40.8	0.0	0.0	0.0	0.0	81.6
	Female	Percent	0.0	0.0	6.1	12.3	0.0	0.0	0.0	0.0	18.4
	Combined	Percent	2.0	6.1	38.8	53.1	0.0	0.0	0.0	0.0	100.0
	(n = 49)[b]	SE (%)	2.2	3.7	7.8	8.9	0.0	0.0	0.0	0.0	
All Creel Survey Sites Combined											
	Male	Percent	3.5	8.9	23.5	19.0	0.0	0.0	0.0	0.0	54.9
	Female	Percent	0.0	0.0	12.6	32.1	0.2	0.0	0.0	0.2	44.1
	Combined	Percent	3.5	8.9	36.1	51.1	0.2	0.0	0.0	0.2	100.0
	(n = 425)[b]	SE (%)	2.4	3.9	8.4	9.7	0.3	0.0	0.0	0.1	
Carcass surveys											
	Male	Percent	2.3	7.3	13.0	20.3	0.6	0.0	0.0	0.0	43.5
	Female	Percent	0.0	0.0	9.0	45.2	1.1	0.0	0.0	1.1	56.5
	Combined	Percent	2.3	7.3	22.0	65.5	1.7	0.0	0.0	1.1	100.0
	(n = 177)[b]	SE (%)	1.1	2.0	3.1	3.6	1.0	0.0	0.00	0.8	
All Sites Combined											
	Male	Percent	3.5	8.5	20.3	19.0	0.2	0.0	0.0	0.0	51.5
	Female	Percent	0.0	0.0	11.7	35.8	0.5	0.0	0.0	0.5	48.5
	Combined	Percent	3.5	8.5	32.0	54.8	0.7	0.0	0.0	0.5	100.0
	(n = 578)[b]	SE (%)	2.6	4.4	9.0	10.3	1.0	0.0	0.0	0.8	

[a] Twenty-eight percent of the Willow Creek mouth harvest consisted of hatchery-produced fish whose age was 0.2 or 0.3. Scales from hatchery-produced fish were indistinguishable from wild fish scales aged 1.2 and 1.3. Therefore, both are included in Willow Creek age groups 1.2 and 1.3.

[b] n = sample size.

Table 4. Mean length (mid-eye to fork-of-tail) in millimeters by sex and age group for Willow Creek chinook salmon from the sport fishery and carcass surveys in 1991.

			Age Group								
Fishery	Sex		1.1	1.2	1.3	1.4	1.5	2.2	2.3	2.4	Total
Mouth[a]:											
	Male	Mean	362	596	781	978	0	0	0	0	
		Standard Error	5.4	5.8	6.3	10.3	0	0	0	0	
		Sample Size	15	40	78	51	0	0	0	0	184
	Female	Mean	0	0	824	937	1,000	0	0	880	
		Standard Error	0	0	6.6	5.5	0	0	0	0	
		Sample Size	0	0	47	118	1	0	0	1	167
	All	Mean	362	596	797	950	1,000	0	0	880	
		Standard Error	5.4	5.8	5.0	5.1	0	0	0	0	
		Sample Size	15	40	125	169	1	0	0	1	351
Parks Highway Bridge and Mid River:											
	Male	Mean	370	572	783	1,009	0	0	0	0	
		Standard Error	0	44.8	11.3	11.6	0	0	0	0	
		Sample Size	1	3	16	20	0	0	0	0	40
	Female	Mean	0	0	813	912	0	0	0	0	
		Standard Error	0	0	14.5	16.2	0	0	0	0	
		Sample Size	0	0	3	6	0	0	0	0	9
	All	Mean	370	572	788	987	0	0	0	0	
		Standard Error	0	44.8	10.0	12.6	0	0	0	0	
		Sample Size	1	3	19	26	0	0	0	0	49
Carcass Surveys:											
	Male	Mean	350	594	807	966	1,020	0	0	0	
		Standard Error	7.1	16.3	14.6	9.3	0	0	0	0	
		Sample Size	4	13	23	36	1	0	0	0	77
	Female	Mean	0	0	851	923	970	0	0	933	
		Standard Error	0	0	8.0	4.8	20.0	0	0	22.5	
		Sample Size	0	0	16	80	2	0	0	2	100
	All	Mean	350	594	825	936	987	0	0	933	
		Standard Error	7.1	16.3	9.8	4.8	20.3	0	0	22.5	
		Sample Size	4	13	39	116	3	0	0	2	177
All Sites Combined											
	Male	Mean	360	594	786	980	1,020	0	0	0	
		Standard Error	8.9	48.0	19.5	18.1	0	0	0	0	
		Sample Size	20	56	117	107	1	0	0	0	301
	Female	Mean	0	0	830	926	980	0	0	915	
		Standard Error	0	0	17.8	17.8	20.0	0	0	22.5	
		Sample Size	0	0	66	205	3	0	0	3	277
	All	Mean	360	594	802	945	990	0	0	915	
		Standard Error	8.9	48.0	14.9	14.4	20.3	0	0	22.5	
		Sample Size	20	56	183	312	4	0	0	3	578

[a] Twenty-eight percent of the Willow Creek mouth harvest consisted of hatchery-produced fish whose age was 0.2 or 0.3. Scales from hatchery-produced fish were indistinguishable from wild fish scales aged 1.2 and 1.3. Therefore, both are included in Willow Creek age groups 1.2 and 1.3.

Table 5. Estimated contribution of hatchery-produced chinook salmon to the Willow Creek sport fishery in 1991.

Coded Wire Tag Number			31-17-60 [a]			31-17-58 [c]			Willow Release Total			31-17-59 [b]			Overall Total		
Strata	Harvest	SE	Hatchery[d]	SE	Percent[e]	Hatchery[d]	SE	Percent[e]	Hatchery[d]	SE	Percent[e]	Hatchery[d]	SE	Percent[e]	Hatchery[d]	SE	Percent[e]
Mouth Survey:																	
I	151	40.2	0	0.0	0.0%	0	0.0	0.0%	0	0.0	0.0%	0	0.0	0.0%	0	0.0	0.0%
II	252	24.7	35	34.4	13.9%	84	45.5	33.3%	119	57.0	47.2%	18	17.4	7.1%	137	59.6	54.4%
III	fishery closed																
IV	1,100	102.7	107	61.0	9.7%	231	80.3	21.0%	338	100.8	30.7%	18	17.7	1.6%	356	102.4	32.4%
V	1,428	210.4	44	43.7	3.1%	286	98.4	20.0%	330	107.7	23.1%	23	22.4	1.6%	353	110.0	24.7%
VI	fishery closed																
VII	66	18.7	0	0.0	0.0%	0	0.0	0.0%	0	0.0	0.0%	0	0.0	0.0%	0	0.0	0.0%
Total	2,997	239.5	186	82.5	6.2%	601	134.9	20.1%	787	158.1	26.3%	59	33.5	2.0%	846	161.6	28.3%
Parks Highway Bridge and Mid River Surveys:																	
IV & V	303	41.6	No coded wire tag recoveries						0	0.0	0.0%				0	0.0	0.0%

[a] Willow Creek 1989 release.

[b] Montana Creek 1988 release.

[c] Willow Creek 1988 release.

[d] Estimated hatchery contribution.

[e] Percent contribution of hatchery-produced fish to the harvest.

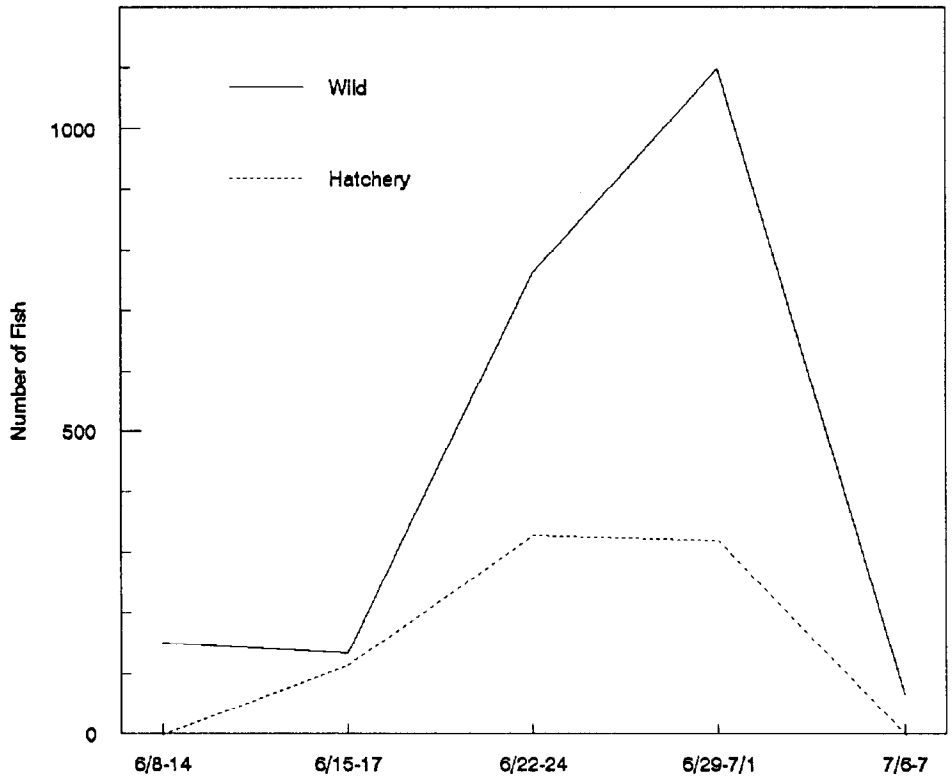

Figure 4. Number of wild and hatchery Willow Creek chinook salmon harvested by strata in 1991.

Carcass surveys on the spawning escapement in Willow Creek above the confluence of Deception Creek resulted in no adipose finclips observed of 270 carcasses examined (Table 2). This indicated no hatchery-produced contribution to the spawning escapement above Deception Creek. Carcass surveys on Willow Creek between the confluence of Deception Creek and the Parks Highway bridge resulted in one adipose finclip observed in 22 carcasses inspected (Table 2). Because of the small sample size, no meaningful hatchery contribution estimate could be calculated. Deception Creek carcass surveys and weir egg take resulted in 309 carcasses examined, 15 adipose finclips observed and 15 heads collected (Table 2). Ten of these tagged fish originated from the Willow Creek 1988 release and one from the Montana Creek 1988 release. No coded wire tags were recovered from the remaining four clipped fish. Based on these tag recoveries, the estimated relative hatchery contribution from fish released into Willow Creek to the Deception Creek escapement was 31% (SE = 9%). The Montana Creek releases relative contribution equaled 2% (SE = 2%).

Tag recoveries occurred in several fisheries for which no hatchery contribution estimates were made (Appendix B3). Three tags from Willow Creek chinook salmon smolt releases were recovered in the Copper River gill net fishery and two tags were recovered in Cook Inlet sport fisheries near Homer.

DISCUSSION

The Willow Creek chinook salmon fishery has existed annually since 1979 (Table 6). However, the fishery has evolved from a weekend-only fishery with a harvest quota of 300 fish to an 18-day season in 1991 with a harvest of 3,000 fish. Harvest patterns have also evolved. The initial fishery in 1979 took place at the Parks Highway bridge. The addition of a road to improve stream access has shifted the majority of the fishery downstream to the stream mouth. Fishery monitoring has changed over time to adjust to changes in the fishery. Consequently, direct comparisons of data among years is in some instances of limited value. It is possible, however, to make some general observations. Participation in the fishery has grown dramatically and harvests have increased over 10 fold (Figure 5). Harvest of wild fish appears to have stabilized and still dominates the catch (Figure 6). Spawning escapements also appear to have stabilized despite the growth in effort and harvest (Figure 7).

Fish Culture

The smolt production goal for the Willow Creek chinook project has now stabilized at 200,000 fish per year. The stocking levels in 1990 and 1991 were substantially higher due to program changes. Fish were stocked in mainstem Willow Creek for the first time in 1991. Previously, all smolt were stocked into Deception Creek, a tributary of Willow Creek. The Deception Creek stocking served two purposes: first, to increase the number of spawners returning to Deception Creek and provide an easily attainable brood stock for maintaining the program; and second, it theoretically isolated hatchery produced spawners from the mainstem Willow Creek spawning population and preserved the genetic integrity of that population component. Thus far, enhanced returns have made brood stock easier to obtain and few hatchery

Table 6. Estimated angler effort, sport harvest, and spawning escapement of Willow Creek chinook salmon for the period 1979-1991.

Year	Location of Creel Survey[a]	Season Length in Days		Effort in Angler Days[b]	Sport Harvest[c]				Willow Creek Escapement Index[d]			Deception Creek Escapement		
		Weekend	Weekday		Total[e]	Wild	Hatchery[f]	Percent Hatchery	Total	Hatchery	Percent Hatchery	Total	Hatchery	Percent Hatchery
1979	Highway	8		975	285	285			848			239		
1980	Highway	8		612	292	292			--[f]			--[f]		
1981	Mouth and highway	8		540	345	345			991			366		
1982	Mouth and highway	8		504	390	390			592			229		
1983	Mouth and highway	8		1,811	393	393			771			121		
1984	Mouth and highway	8		1,939	805	805			2,789			675		
1985	Mouth and highway	8		2,338	763	763			1,856			1,044		
1986	Mouth and highway	8		2,313	1,043	1,043	--[g]		2,059	--[g]		521	157	30.1
1987	Mouth, highway, Susitna Landing	8	4	3,770	1,720	1,720	--[g]		2,768	--[g]		692	174	25.1
1988	Mouth, highway, Susitna Landing	8	4	5,444	2,160	1,858	302	14.0	2,496	--[g]		790	237	30.0
1989	Mouth, highway, Susitna Landing	8	8	8,685	2,570	1,598	972	37.8	5,060	153	3.0	800	160	20.0
1990	Mouth and highway	8	10	9,313	2,789	1,773	1,016	36.4	2,365	50	2.1	700	339	48.4
1991	Mouth	10	8	10,461	2,997	2,210	787	26.3	2,006	0	0.0	747	232	31.1

[a] Creel survey sites changed from year to year to accommodate the evolving fishery and remain representative of the harvest and effort.

[b] Source of data: 1979, Watsjold 1980; 1980, Watsjold 1981; 1981, Bentz 1982; 1982, Bentz 1983; 1983, Hepler and Bentz 1984; 1984, Hepler and Bentz 1985; 1985, Hepler and Bentz 1986; 1986, Hepler and Bentz 1987; 1987, Hepler et al., 1988; 1988, Hepler et al., 1989; 1989, Sweet and Webster 1990; 1990, Sweet et al., 1991. In years where effort in angler-days was not reported total estimated effort was divided by the mean length of the angler-day to obtain the number of angler-days.

[c] A harvest quota of 300 chinook salmon governed the fishery from 1979 thru 1983.

[d] Escapement index counts are from aerial counts during peak spawning activity.

[e] All harvest estimates are from inseason creel surveys.

[f] All hatchery harvest estimates are from coded wire tag recovery programs associated with the creel survey.

[g] Small numbers of hatchery fish probably returned but recovery of coded wire tags was not recorded. All production was attributed to wild fish returns.

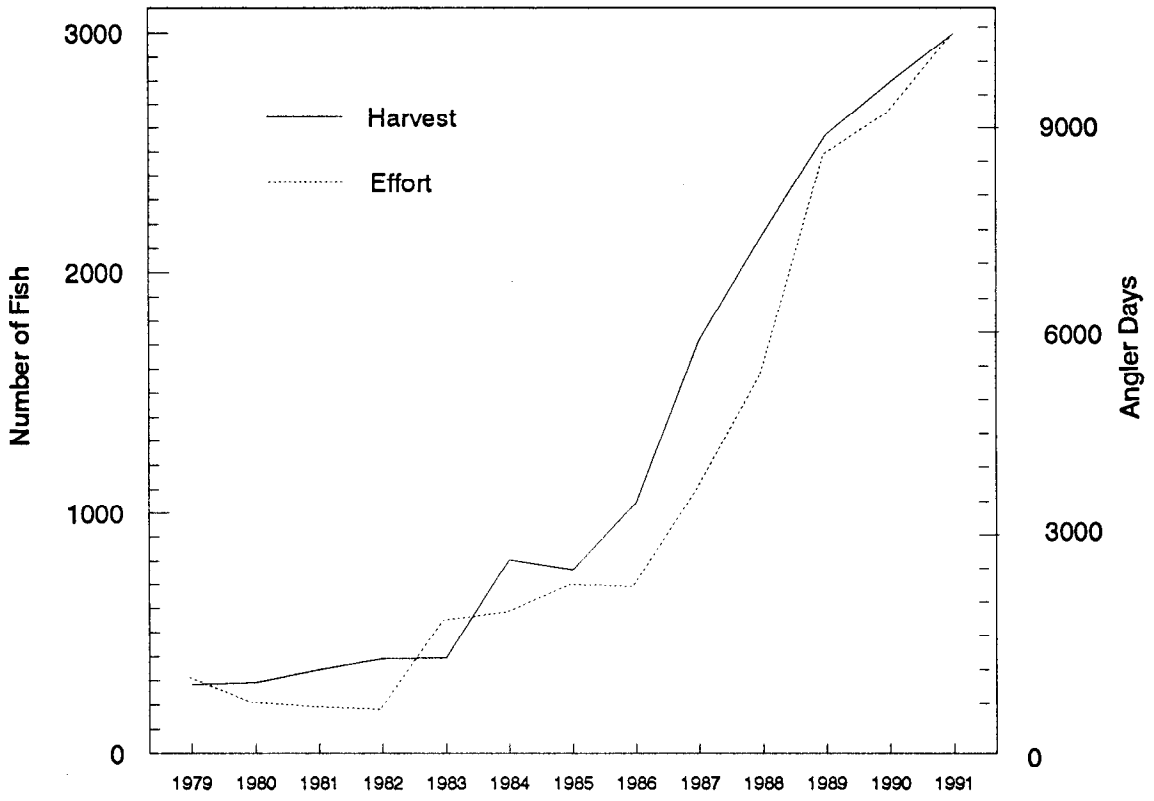

Figure 5. Numbers of chinook salmon harvested and angler days of effort expended sport fishing on Willow Creek, 1979-1991.

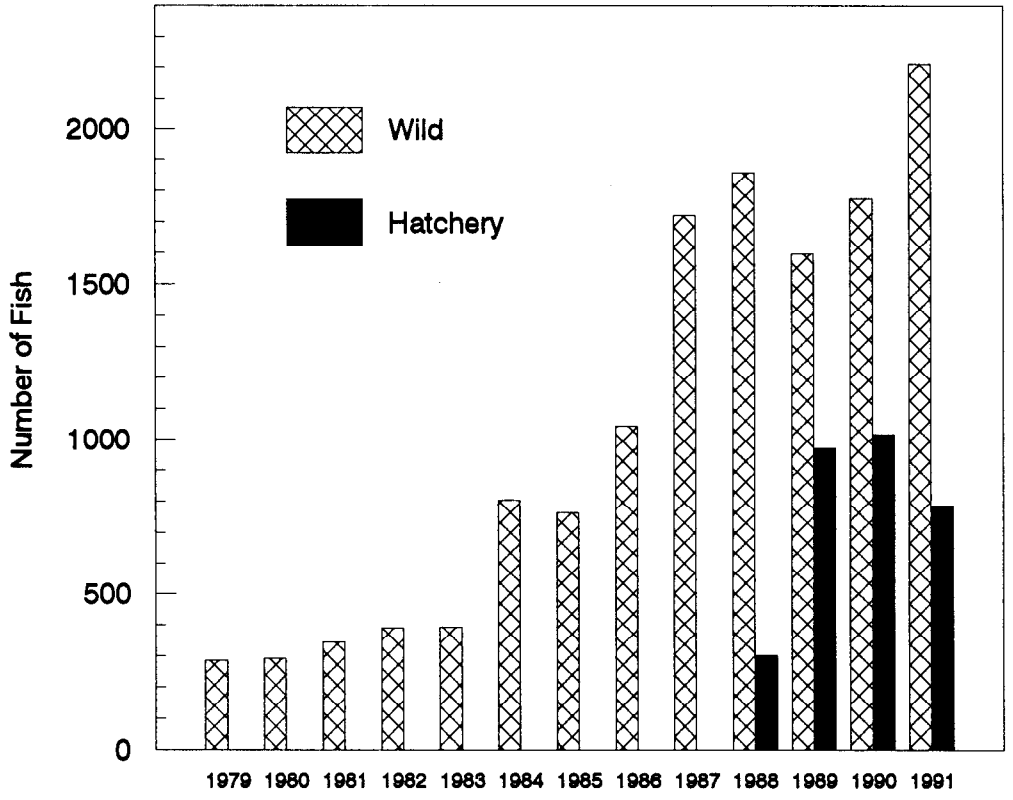

Figure 6. Numbers of wild and hatchery Willow Creek chinook salmon harvested, 1979-1991.

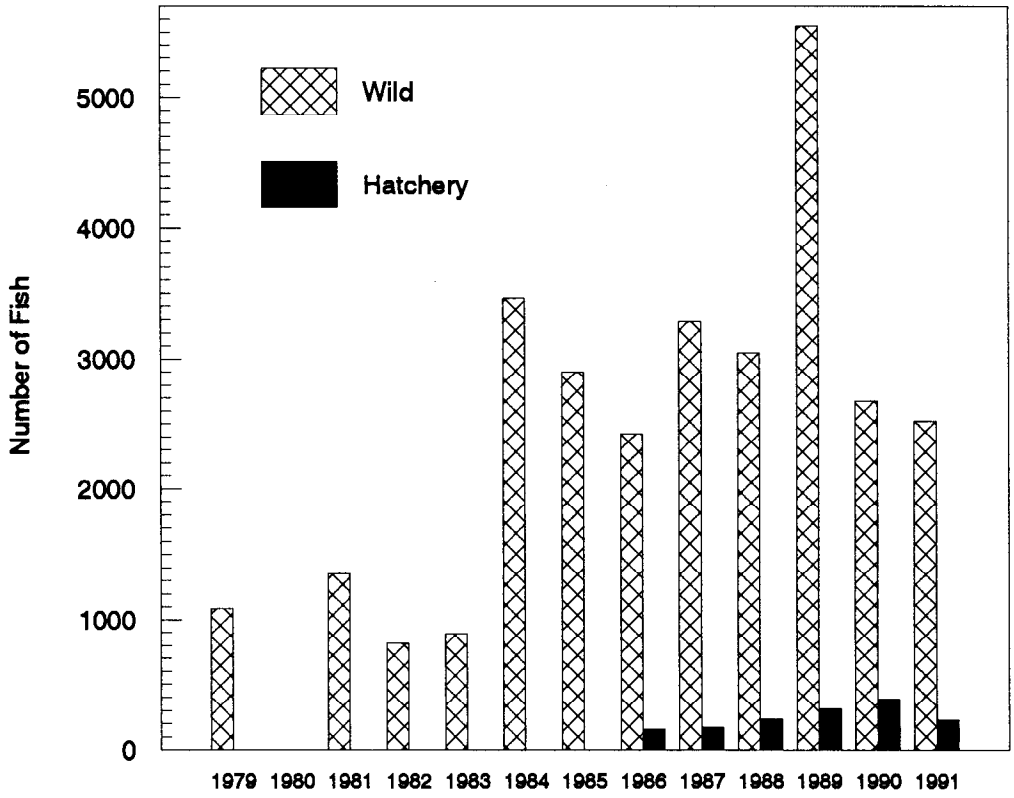

Figure 7. Numbers of wild and hatchery chinook salmon in the Willow Creek and Deception Creek escapement index, 1979-1991. The 1986-1988 hatchery estimate includes Deception Creek escapement only.

produced spawners have been documented spawning in mainstem Willow Creek (Appendices B4 and B5). Splitting the stocked smolt between the two stocking sites will probably not significantly reduce our ability to obtain brood stock. However, stocking fish in mainstem Willow Creek will undoubtedly result in increased numbers of hatchery returns spawning with returning wild fish in mainstem Willow Creek. The Willow Creek location is a much better stocking site. It is a deep backwater area with no current which provides the stocked fish with an excellent area to rest and recover from the stress of transport. In addition, it provides easy access and turn around for the hatchery transport truck. We feel that segregating hatchery and wild spawners is potentially more important than providing a better stocking site. Consequently, all future stocking should be restricted to Deception Creek.

The 1991 egg take of 430,000 eggs was sufficient to meet the program goal and provide eggs for an associated project. However, due to a decrease in the number of eggs necessary to conduct this and associated programs, only 107 fish were used for brood stock. According to the Alaska Department of Fish and Game Genetic Policy (Davis 1985), a minimum effective population (N_e) of 400 should be maintained. The policy also states that small population sizes may be unavoidable with chinook salmon populations and a breeding plan should be developed with the help of the FRED Division principal geneticist. Future planning for this program should include development of a breeding plan.

Approximately 20% of the release was to have been coded wire tagged. In 1991, the appropriate number of fish were tagged, but due to poor tag retention a large portion of the adipose clipped fish released (26.2%) did not have a valid coded wire tag. This poor tag retention could cause problems with future data interpretation. Tagging in 1992 will be performed under a rigid set of guidelines to be described in the 1992 operational plan.

Creel Statistics

The results of the creel survey in 1991 indicated that the majority of angler effort (93%) and fish harvest (91%) occurred at the mouth of Willow Creek. It appears the fishing that occurred upstream from the mouth of Willow Creek is too small to justify the expense of inclusion in the creel program. However, in 1992, the season will likely be extended later into July allowing anglers increased access to the main portion of the run. This should result in an increase in upstream angler effort and harvest over 1991. Consequently, we recommend that the midriver and Parks Highway bridge creel surveys be continued in 1992. The delta fishery survey was run to determine if a need existed for creel survey coverage of this area. The resulting 412 angler-hours of effort is not large enough to justify a repeat of the survey in 1992.

Escapement Statistics

The spawning escapement surveys on Willow and Deception creeks served as functional indices of the spawning population. These surveys were necessary to measure the effectiveness of fisheries management in obtaining the escapement objective. The main function of the carcass surveys was to estimate the hatchery contribution to the mainstem of Willow Creek and Deception Creek. To date, few hatchery produced fish have spawned in mainstem Willow Creek, but substantial numbers have spawned in Deception Creek (Appendix B4). Hatchery returns in 1992 will be the largest to date.

Therefore, carcass surveys on the mainstem of Willow Creek and Deception Creek should continue in 1992 to determine if hatchery returns will be spatially isolated from wild fish in the mainstem of Willow Creek. This information could prove to be very useful in planning future enhancement projects. The survey of Willow Creek below the mouth of Deception Creek should be eliminated. This stretch of the stream is small and little information was obtained in 1991. In addition, carcasses found in this stretch of the stream could have been from either Deception or Willow creeks, thus the information has limited value.

Size, Sex, and Age Compositions

The majority of samples for age, length, and sex were obtained from the mouth fishery (62.5%) with lesser amounts from the Parks Highway/midriver fisheries (8.1%) and the carcass surveys (29.4%). Age, length, and sex parameters between the mouth fishery and the Parks Highway/midriver fisheries were comparable. However, comparison of age composition data between all creel survey sites and the carcass survey revealed a higher occurrence of age-1.4 fish in the carcass sample. This phenomenon may be attributable to the physical attributes of the sampling strategies. Samples were obtained from fish which were visible and accessible in the carcass survey. Carcasses of larger fish were definitely more visible. In addition, large fish probably had a reduced chance of washing downstream or being carried off by scavengers and predators than small fish. On the other hand, the creel survey sampled whatever fish the anglers caught and retained. Size selectivity could have occurred in the angler harvest. Large chinook salmon may be more difficult to catch and land. Consequently, they could have a reduced opportunity to show up in the creel survey. If catch rates were good, anglers may have caught and released smaller fish in hope of harvesting a larger fish. It is not possible to determine if one sampling strategy provides a better estimate of the true age composition of the chinook salmon population than another. Both sampling strategies should be maintained.

It is possible to use historical age, length, and sex data from sport harvested chinook salmon from Willow Creek to determine trends in these parameters for the sport harvested population. Age composition data based on sport harvest exist since 1979 (Appendix B6). If we assume that the age composition of the escapement is the same as the age composition in the sport harvest, we can construct a brood table which lists the age composition by brood year rather than year at return (Table 7). The majority of fish (60.3%) return after 4 years residence in the ocean with lesser numbers after 3 (26.7%) and 2 (13.0%) years (Figure 8). Comparable length (Appendix B7) and sex (Appendix B8) data exist from creel survey information collected since 1986. Sex composition in the sport harvest varies among age classes. The majority of 2-ocean (96.6%) and 3-ocean (62.6%) fish return as males while most 4-ocean (65.8%) fish return as females (Figure 9). The variability among years is minimal. Length differences among age classes in the sport harvest are obvious with age 2-, 3-, and 4-ocean fish averaging 602, 827, and 949 mm, respectively (Figure 10). For all years, 3-ocean females are larger than 3-ocean males, but 4-ocean females are smaller than 4-ocean males. Only data collected from the sport harvest were included in this historic database.

Table 7. Estimated age at return of Willow Creek chinook salmon by brood year based on sport harvest data collected during the period 1979-1991.

Brood Year[a]	Origin	Estimated Number Returning by Age Class[bc] 1.2	1.3	1.4	Total Return	Estimated Percent Returning by Age Class[b] 1.2	1.3	1.4	Total Return
1973	Wild			1,043	1,043				
1974	Wild		192	155	347				
1975	Wild	137	53	885	1,075	12.8	4.9	82.3	100.0
1976	Wild	85	613	908	1,606	5.3	38.2	56.6	100.0
1977	Wild	204	218	514	936	21.8	23.3	54.9	100.0
1978	Wild	85	386	2,006	2,477	3.4	15.6	81.0	100.0
1979	Wild	386	1,708	1,502	3,595	10.7	47.5	41.8	100.0
1980	Wild	555	1,136	1,667	3,357	16.5	33.8	49.6	100.0
1981	Wild	513	1,775	2,124	4,412	11.6	40.2	48.1	100.0
1982	Wild	543	984	1,906	3,434	15.8	28.7	55.5	100.0
1983	Wild	1,450	926	6,238	8,614	16.8	10.7	72.4	100.0
1984	Wild	871	1,602	2,986	5,459	16.0	29.3	54.7	100.0
1985	Wild	590	995	3,048	4,633	12.7	21.5	65.8	100.0
1986	Wild	850	1,295		2,145	39.6	60.4	0.0	100.0
	Hatchery	1,023	833		1,856	55.1	44.9	0.0	100.0
	Total	1,873	2,128		4,001	46.8	53.2	0.0	100.0
1987	Wild	353			353	100.0			100.0
	Hatchery	222			222	100.0			100.0
	Total	575			575	100.0			
Brood Years 1975 to 1985					Mean	13.0	26.7	60.3	100.0
					Maximum	21.8	47.5	82.3	
					Minimum	3.4	4.9	41.8	

[a] Wild fish are all age-1 fresh water and hatchery fish are all age 0. Hatchery fish and wild fish are grouped by smolt year. The brood year for hatchery fish is actually N+1.

[b] Other age classes exist (1.1, 1.5, 2.2, 2.3, 2.4, 2.5) but never make up more than 5% of the return on a combined basis.

[c] These data assume the age composition of the Willow Creek escapement and sport harvest are comparable.

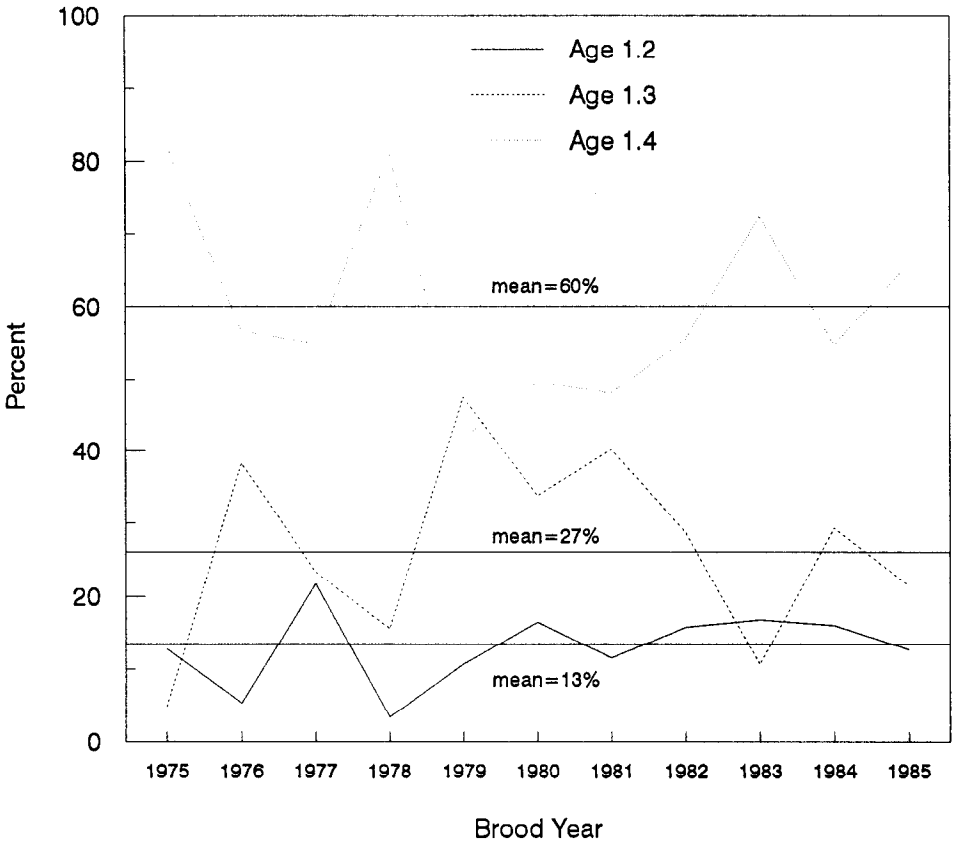

Figure 8. Willow Creek chinook salmon estimated age at return for brood years 1975-1985 based on sport harvest data.

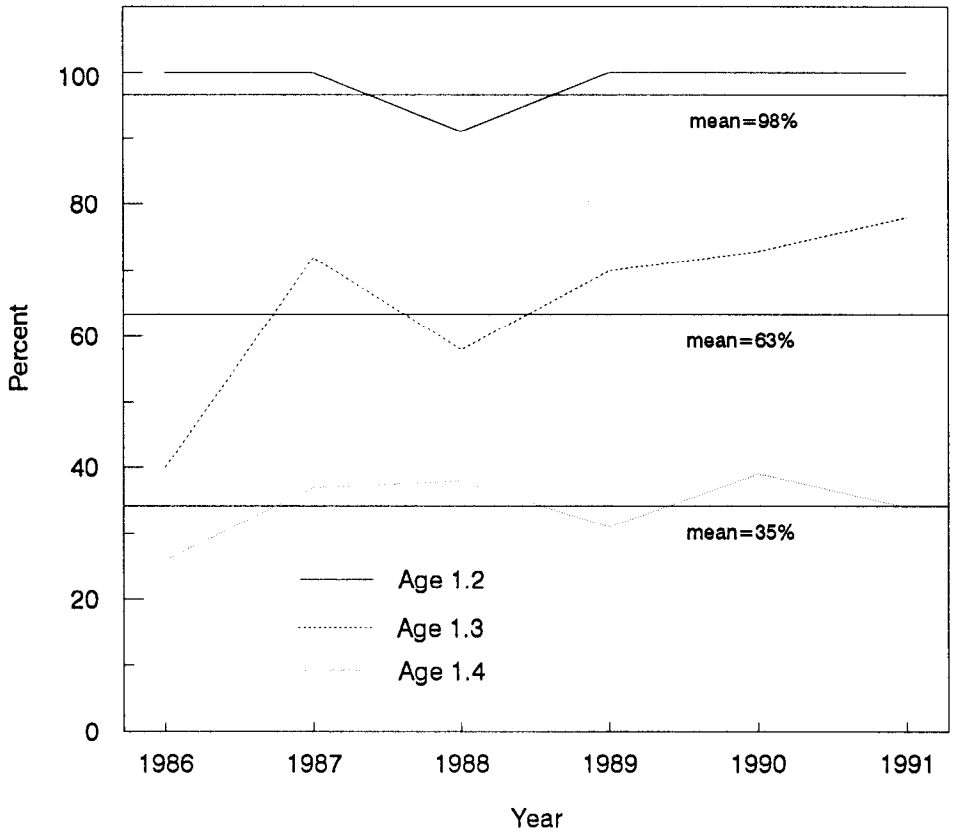

Figure 9. Willow Creek chinook salmon estimated percentage of males by age class from sport harvests for the period 1986-1991.

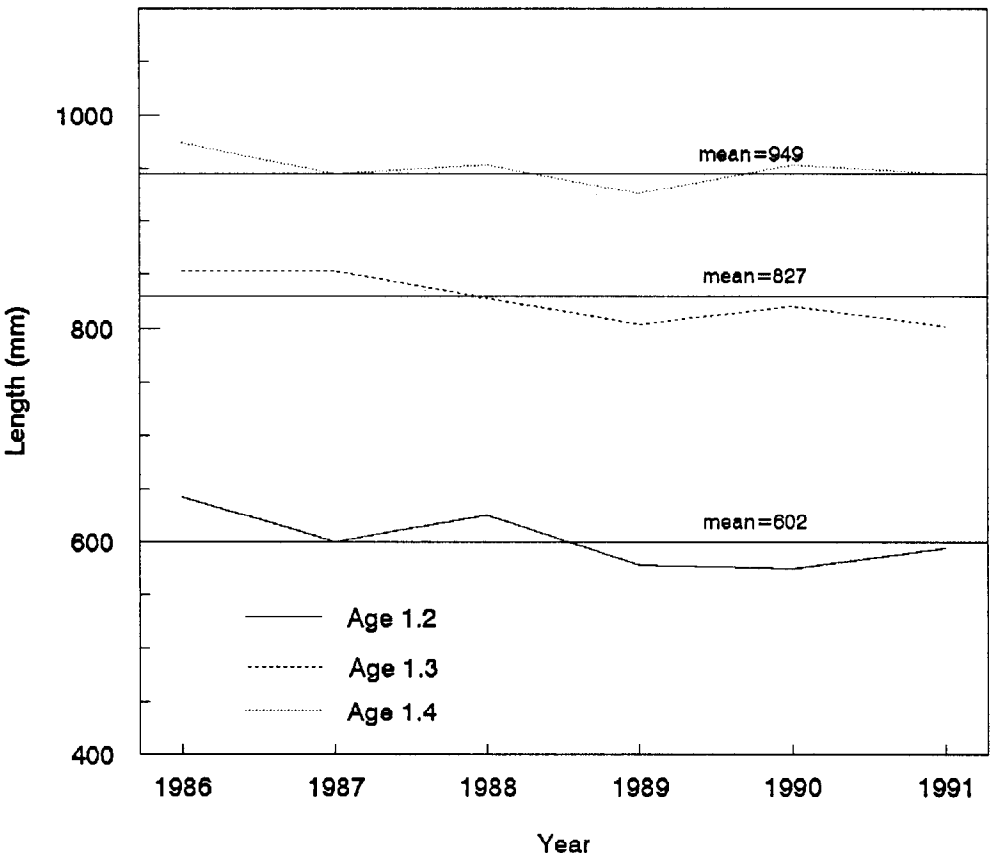

Figure 10. Willow Creek chinook salmon estimated mean length by age class from sport harvests for the period 1986-1991.

Contribution of Coded Wire Tagged Stocks

The 1991 estimated hatchery contribution to the Willow Creek chinook salmon fishery declined below the estimated level of previous years (Table 6). This was primarily due to lack of a 4-ocean hatchery component which normally comprises the majority of the return. There was a break in the production cycle with brood year 1986. No eggs were taken that year because of construction activities to correct water problems at Fort Richardson hatchery. Performance of hatchery smolt stockings at Willow Creek has been well below expectations. Seven brood years of chinook salmon smolt have been stocked since the Willow Creek project started in 1983 (Appendix B1). Returns from brood years 1983, 1984, and 1985 are completed and were far below expectations (Figure 11). Although still incomplete, returns from subsequent brood years have improved and are much closer to returning at projected levels.

Enhancement Program Evaluation

Success of the Willow Creek chinook salmon enhancement program was measured through attainment of the stated objectives and goals.

The escapement indices to Willow and Deception creeks since 1987 have been below the 4,500 fish escapement objective every year except 1989 (Figure 7). The escapement indices are a combination of peak aerial survey and foot counts and are therefore not directly comparable to an absolute escapement objective. In recent years, the indices have totaled approximately 3,000 fish on an annual basis. If we assume that the indices account for no more than two-thirds of the actual escapement, it is reasonable to expect that the 4,500 fish escapement objective has been achieved or at least approached very closely. To avoid future confusion, it may be appropriate to restate the escapement objective in terms of the escapement indices rather than an absolute number.

The stocking objective of 200,000 chinook salmon smolt to Willow Creek has been exceeded every year except the initial brood year of 1983 and brood year 1986 when no eggs were taken (Appendix B1). However, less than a 1% survival rate has been observed. It should be noted that the smolt stocked from the first 3 brood years were subject to a different rearing regime than those stocked in subsequent years. During the period 1983 to 1986, Fort Richardson hatchery experienced numerous operational problems. Gas supersaturation and periodic losses of water resulted in the production of smolt which had been subjected to extended periods of stress. In 1986, production at the hatchery was curtailed while more wells, heat exchangers, and oxygen contactors were added. Smolt produced during 1987-1990 were not subjected to long periods of stress and have been subjectively considered better quality smolt than previous brood years. None of these brood years have experienced a complete return of all year classes, but the survival rates appear to have improved.

We do not have enough data to determine if historical age and sex compositions have been maintained. Returns from the first 3 brood years were too small to provide any meaningful information to the database. Returns from subsequent brood years are not yet complete. The historic age and sex data compiled in Appendices B6 and B8 as well as Figures 8 and 9 should provide a basis for future comparison.

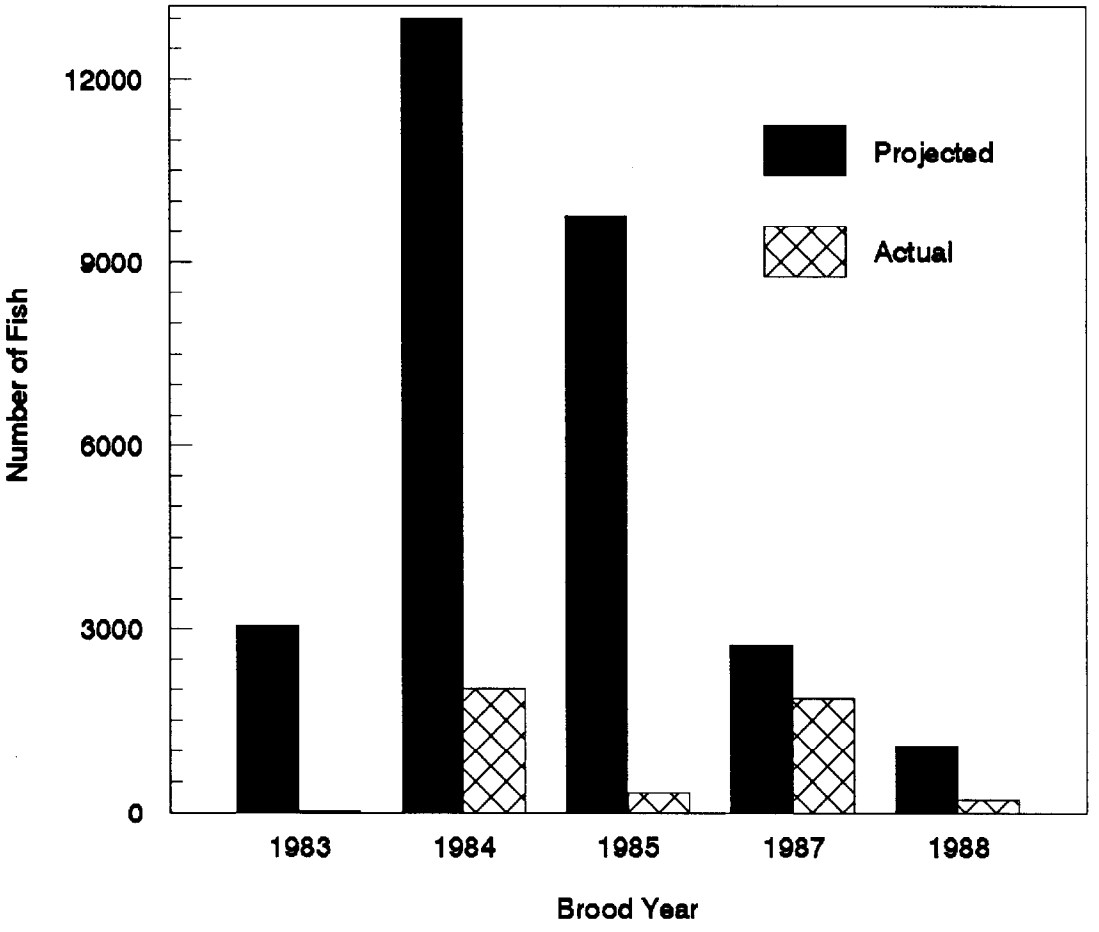

Figure 11. Projected and actual hatchery returns of Willow Creek chinook salmon by brood year from return years 1986-1991. Projections are through 1991 only.

The last objective to measure performance of the enhancement program was to provide 10,000 additional angler-days of participation during weekdays in June. Historic fishing effort is listed in Table 6. The number of angler-days of fishing effort per year has increased continuously since 1982. The increase in effort coincides with an increase in harvest of both wild and hatchery produced fish. In order to determine the amount of fishing effort created by the addition of hatchery produced fish, we must establish a baseline for effort which would exist if only wild fish were present. Hatchery fish first showed up in the sport harvest in appreciable numbers in 1988. The sport harvest of wild fish has been relatively stable since that point in time, while hatchery harvests have increased. In addition, season length in terms of weekdays open to fishing has increased from 4 to a minimum of 8 days since 1988. It is assumed that these additional fishing days were added in anticipation of increased hatchery returns. Based on this information and the need to establish a baseline measurement for comparative purposes, it seems reasonable to use the amount of fishing which occurred in 1988 as our baseline. Consequently, approximately 5,000 angler days of fishing effort have been added at Willow Creek since 1988 and are attributable to enhancement. Historic data analysis has been performed by strata rather than individual days. Most strata do not differentiate between weekends and weekdays. It is impossible to determine whether this increased effort has occurred on weekdays, as stated in this objective, without reanalyzing all historic data.

The historic quality and quantity of natural chinook salmon production has been maintained as evidenced by attainment of the annual 4,500 fish escapement (natural production). However, lack of substantial age and sex composition data from enhanced returns prevents us from measuring maintenance of fish quality. Comparison of future age and sex composition data to the historic baseline data will allow us to make this determination in the future. Another indicator of quality is maintenance of historic fish size. Here again, a more meaningful comparison can be made as more data are collected in the future. The last indicator of quality is maintenance of historic harvest timing (Appendix B9). The 1991 fishery harvest pattern is similar to the historic mean (Figure 12). Although the database is limited, the harvest timing does not appear to have changed.

We have not come close to achieving our second program goal of producing an additional 6,000 returning chinook salmon adults of which 4,000 will be available for harvest in Willow Creek. Returns from the first 3 brood years were dismal failures. However, returns from subsequent releases indicate that the difference between projected and actual returns is decreasing (Figure 13). Utilizing data from the brood table (Table 7) and historic age composition (Appendix B5) allows us to project 1992 returns (Appendix C3). Based on returns of 2- and 3-ocean fish from 1990 and 1991, we can expect an estimated 4-ocean return of 6,077 fish (3,258 wild, 2,819 hatchery). Likewise, based on the return of 2-ocean fish in 1991, we can expect a 3-ocean return of approximately 1,181 fish (799 wild, 382 hatchery). Based on the 1990 smolt release, an estimated marine survival of 3%, and a 2-ocean return of 13%, we can expect an estimated 2,556 hatchery fish to return as 2-ocean fish. If we include a wild 2-ocean return estimate equal to the historic mean, the estimated 1992 chinook salmon return to Willow Creek should be at least 10,000 fish, of which approximately 56.5% will be of hatchery origin. The largest drawback to this approach is the fact that Willow Creek chinook salmon are

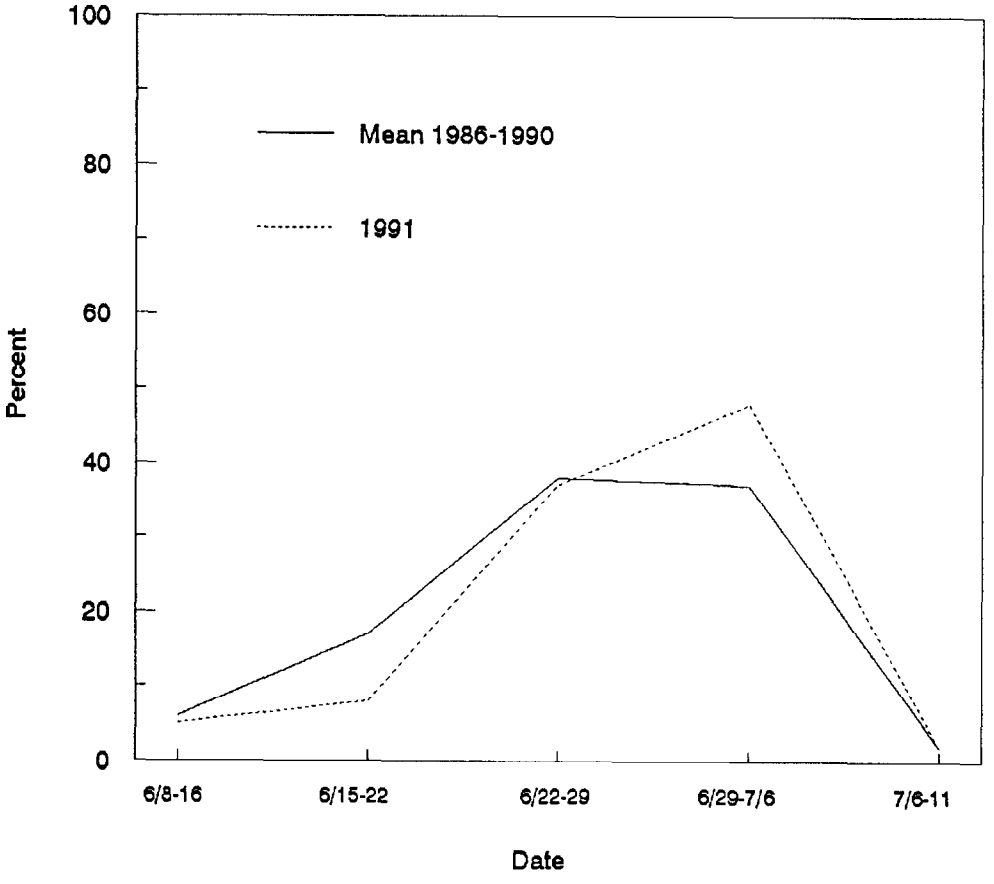

Figure 12. Comparison of 1991 Willow Creek chinook salmon harvest timing to the mean for the period 1986-1990.

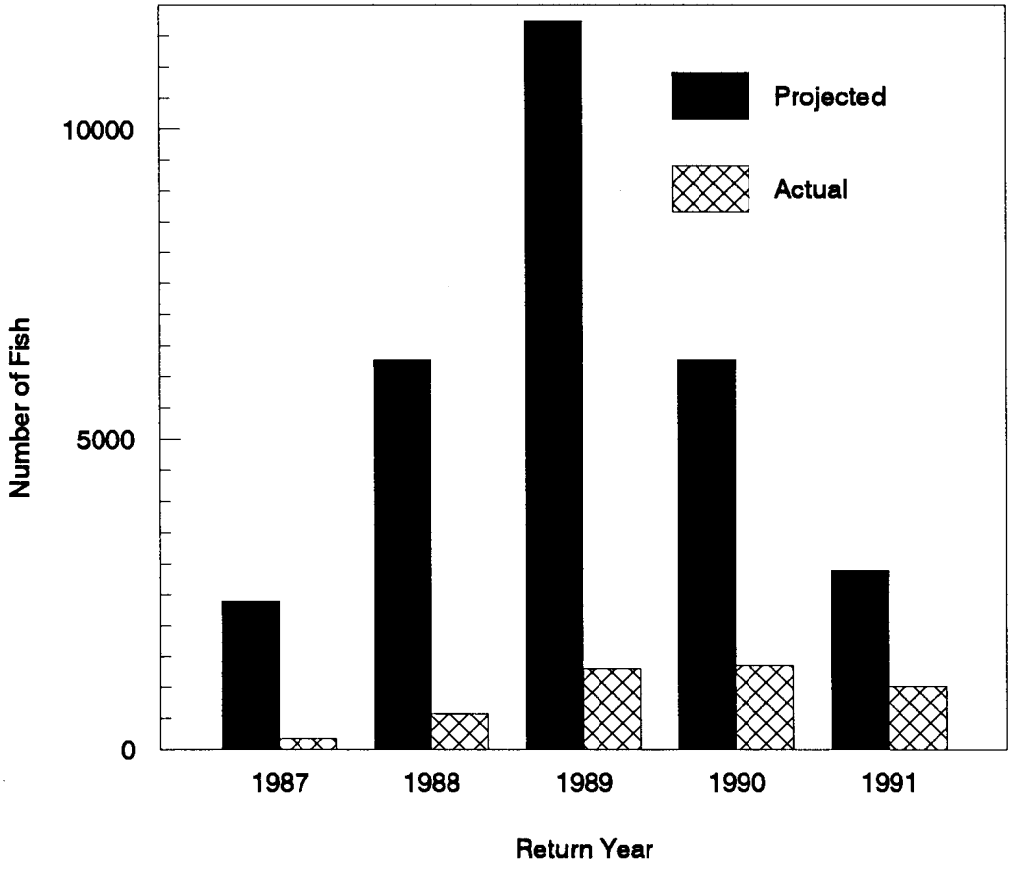

Figure 13. Willow Creek chinook salmon projected and actual hatchery returns for the period 1987-1991.

harvested without any enumeration in several nontarget fisheries. If this harvest is constant over time, then this approach to predicting returns should be successful. If the 1992 projections prove to be accurate, then we may be able to achieve our program production goal in 1992. In addition, utilizing brood tables may prove to be an excellent method for predicting future returns and serve as powerful tools for fishery managers.

The last program goal to examine involves providing additional angler opportunity. Based on data interpretation associated with objective number 4, the Willow Creek chinook salmon enhancement program has added approximately 5,000 angler days of fishing effort. This is half of the stated goal. The goal also states that the effort should be added during weekdays. Due to the present methodology of data collection and analysis, it is impossible to totally separate weekends and weekdays. Our discussion of this goal will center around providing 10,000 additional angler days of fishing effort and not be concerned with the temporal distribution. In order to standardize data collection among years, the Willow Creek chinook salmon creel survey has historically started on the second Saturday in June and extended through the early part of July. In 1991 there were 10 potential weekend days of fishing and 20 potential weekday days. Fishing was open all 10 of the weekend days and 8 of the 20 potential weekday days. The 18 days of fishing generated 10,461 days of angler effort or an average of 581 angler days of effort per day. If this level of effort could be maintained for the additional available 12 days, then we could theoretically produce another 6,972 (12 x 581) angler days of effort. It may also be possible to add more effort on the days currently open. However, the amount of space available for anglers to fish at the mouth of Willow Creek is limited and access to the rest of Willow Creek is also limited. Current levels of effort may be close to saturating all available fishing space. If the anticipated increase in fish available for harvest in 1992 materializes, angler effort trends next year should reveal whether the Willow Creek mouth fishery can generate additional fishing effort.

This report establishes the database for measuring the performance and success of the Willow Creek chinook salmon enhancement program. The developmental phase of this program is scheduled to be completed by 1994. Following data collection in 1994, a program completion report will be written. All existing data will be incorporated into this database to develop conclusions and make a recommendation as to whether the Willow Creek chinook salmon enhancement program should be discontinued, continued, or modified.

Recommendations

Based on data analysis and discussion presented in this report, we recommend the following:

1. The stocking of smolt in mainstem Willow Creek should be discontinued. At this point in time it is desirable to spatially isolate returning hatchery produced spawners from wild spawners.

2. Brood stock requirements (approximately 100 fish) will remain at existing levels for the next few years. Since the level of brood stock currently being used is far below the desired level (400 fish) stated in the State of Alaska Genetic Policy, a breeding plan should be developed with the assistance of the department geneticist.

3. Coded wire tagging should be more rigidly monitored to insure better quality control during tagging and equal mixing of tagged and untagged groups prior to release. A tagging operational plan will be written and followed in 1992.

4. The upstream creel surveys should continue in 1992. The open fishing period extends later into July allowing increased fishing opportunity for anglers during the main part of the run. The delta area effort survey should not continue in 1992. The angling effort in this area was not great enough to warrant a survey.

5. Carcass surveys should continue for at least one more year to determine if hatchery fish are spawning with wild fish in mainstem Willow Creek, but the area below the mouth of Deception Creek should be eliminated from the survey.

6. We should continue to obtain age, length, and sex data from sport harvests and carcass surveys. We have not determined which is a better indicator of the true population characteristics, and both are needed to fully evaluate return information.

7. The escapement objectives for the program are stated in absolute numbers while the escapement is monitored by indices. The escapement objectives should be restated so that the objectives can be directly compared to the indices for measurement of compliance.

8. The brood table developed has potential as a valuable management tool. This data should be further refined and yearly projections should be used to help form management strategies for the upcoming year.

ACKNOWLEDGMENTS

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APPENDIX A

Appendix A1. Willow Creek chinook salmon creel survey strata definitions and sampling location parameters, 1991.

Strata for the 1991 Willow Creek chinook salmon creel survey were defined as follows:

Mouth Fishery:	I	= 8 June - 14 June;
	II	= 15 June - 17 June;
	III	= 18 June - 21 June;
	IV	= 22 June - 24 June;
	V	= 29 June - 1 July;
	VI	= 2 July - 5 July;
	VII	= 6 July - 7 July.
Delta Fishery:	II	= 15 June - 17 June.
Mid River Fishery:	IV	= 22 June - 24 June
	V	= 29 June - 1 July;
Parks Highway Fishery:	IV	= 30 June - 2 July;
	V	= 3 July - 4 July.

Mouth Fishery:

A summary of the sampling characteristics for the mouth fishery component of the creel survey is as follows:

1. Dates: 8 June thru 7 July, Strata I, II, IV, V, and VII. Fishery was closed during strata III and VI.

2. Fishing and sampling period: 24 hour fishing day consisting of six 4-hour periods.

3. All days before 15 June, except 11 and 12 June which were days off, were sampled two periods, weekends (Saturday, Sunday, and Monday) after 15 June were sampled four periods and weekdays were sampled two periods.

4. Three systematic angler counts (each 1 hour and 20 minutes apart, taking 20 minutes to conduct) were taken each period (start time for first count was selected at random).

Delta Fishery:

A survey was conducted in the delta area to estimate angler effort from boat fishermen who were not monitored by the mouth fishery component of the creel survey. A summary of the sampling characteristics for the delta fishery is as follows:

-continued-

1. Dates: 15 June thru 17 June. Strata II.

2. Fishing and sampling period: 16-hour fishing day consisting of four 4-hour periods.

3. Two of the 4-hour periods were sampled each day selected.

4. Three systematic angler counts (each 1 hour and 20 minutes apart, taking 20 minutes to conduct) were taken each period (start time for first count was selected at random).

Midriver Fishery:

A summary of the sampling characteristics for the mid river fishery component of the creel survey is as follows:

1. Dates: 22 June thru 1 July. Strata IV and V.

2. Fishing and sampling period: 16-hour fishing day consisting of four 4-hour periods.

3. Two of the 4-hour periods were sampled each day selected for sampling.

4. One systematic angler count each period (taking 30 minutes to conduct) was taken for all days surveyed except one. In order to evaluate the degree of bias in our variance estimates, three angler counts were conducted each period during this one day.

Parks Highway Fishery:

A summary of the sampling characteristics for the Parks Highway fishery component of the creel survey is as follows:

1. Dates: 29 June thru 1 July. Strata V.

2. Fishing and sampling period: 24-hour fishing day consisting of six 4-hour periods.

3. Four of the 4-hour periods were sampled each day.

4. Three systematic angler counts (each 1 hour and 20 minutes apart, taking 20 minutes to conduct) were taken each period (start time for first count was selected at random).

Appendix A2. Estimation equations for catch per unit of effort as an index of abundance for the creel survey conducted during 1991 on the chinook salmon sport fishery in Willow Creek.

Estimates of catch per unit of effort (CPUE) as an index of abundance for the 1991 Willow Creek chinook salmon sport fishery were obtained by first obtaining the CPUE for each angler:

$$CPUE_{hijk} = \frac{c_{hijk}}{e_{hijk}} ; \qquad (A2.1)$$

where: c_{hijk} and e_{hijk} equal the catch and effort of each interviewed completed-trip angler, respectively (note that the subscript h refers to time period or stratum.

The mean CPUE for each section and time period of the fishery was then calculated over all anglers interviewed within each section and time period:

$$\overline{CPUE_h} = \frac{\sum_{i=1}^{d_h} \sum_{j=1}^{p_{hi}} \sum_{k=1}^{m_{hij}} CPUE_{hijk}}{m} ; \qquad (A2.2)$$

where: m_{hij} equals the number of anglers interviewed within each period; p_{hi} equals the number of periods sampled within each day; d_h equals the number of days sampled within each time period and section; and m equals the total number of anglers interviewed within each period and section, obtained as;

$$m = \sum_{i=1}^{d_h} \sum_{j=1}^{p_{hi}} m_{hij} . \qquad (A2.3)$$

The variances of the time period and section estimates of CPUE were obtained by the following equation:

$$\hat{V}[\overline{CPUE_h}] = \frac{\sum_{i=1}^{d_h} \sum_{j=1}^{p_{hi}} \sum_{k=1}^{m_{hij}} (CPUE_{hijk} - \overline{CPUE_h})^2}{m\,(m-1)} . \qquad (A2.4)$$

Appendix A3. Estimation equations for the distribution of catches and harvests for the creel survey conducted during 1991 on the chinook salmon sport fishery in Willow Creek.

The distribution of catches and harvest as described in the body of this report were estimated as described below for the 1991 survey. We first coded the data to correct for possible biases due to changing amounts of angler effort (in terms of angler-trips). From Sukhatme et al. (1984: equation 8.58; page 327):

$$y_{khijo} = \begin{cases} \hat{M}_{hij} / \bar{\hat{M}}^{*}_{hi} & \text{if harvest made by interviewed angler } o \text{ during sample } j \text{ on day } i \text{ within stratum } h \text{ caught k or more chinook salmon (or zero chinook salmon if k = 0);} \\ 0 & \text{otherwise;} \end{cases} \quad \text{(A3.1)}$$

where:

$\hat{M}_{hij}$ = estimated number of angler-trips for each sample, obtained from the ratio of the estimated angler effort for the sample divided by the mean angler effort from interviewed anglers for the sample;

$$= \frac{\hat{E}_{hij}}{\bar{e}_{hij}} ; \quad \text{(A3.2)}$$

$\hat{E}_{hij}$ is the angler effort estimate for the sample (as obtained from equation 32 in Bartlett and Bingham 1991);

$\bar{e}_{hij}$ = the mean angler effort expended by anglers interviewed within each sample for their trip of fishing;

$$\frac{\sum_{o=1}^{m_{hij}} e_{hijo}}{m_{hij}} ; \quad \text{(A3.3)}$$

-continued-

$\bar{\hat{M}}^{*}_{hi}$ = the "restricted" mean of the possible number of angler-trips for each day estimated as the mean of the number of angler-trips (restricted to periods in which one or more angler-trips are estimated):

$$= \frac{\sum_{j=1}^{p^{*}_{hi}} \hat{M}^{*}_{hij}}{p^{*}_{hi}} ; \qquad \text{(A3.4)}$$

$\hat{M}^{*}_{hij}$ = estimated as in equation A3.2, above, but restricted to only estimates that are greater than zero;

p^{*}_{hi} equals the number of periods during each day with at least one angler-trip estimated; and all other terms are as defined above.

The angler met the criterion if his or her harvest $h_{hijo} \geq k$ where $k = 1$ to k_{max} or $h_{hijo} = 0$ for $k = 0$; otherwise $y_{khijo} = 0$. The data were recoded for each iteration from 0 to k_{max}. After coding, the average fraction and its variance were found for each stratum:

$\equiv$
y_{kh} = estimated proportion of angler-trips in each stratum that harvest 0 or at least k chinook salmon;

$$= \frac{\sum_{i=1}^{d_h} y_{khi}}{d_h} ; \qquad \text{(A3.5)}$$

where:

$=$
y_{khi} = mean proportion of angler-trips for day i that harvest 0 or at least k chinook salmon;

$$= \frac{\sum_{j=1}^{p^{*}_{hi}} \bar{y}_{khij}}{p^{*}_{hi}} ; \text{ and} \qquad \text{(A3.6)}$$

-continued-

$\bar{y}_{khij}$ = mean sample proportion of angler-trips for each sample that harvest 0 or at least k fish;

$$= \frac{\sum_{j=1}^{m_{hi}} y_{khijo}}{m_{hi}} . \quad \text{(A3.7)}$$

The variance of the estimated proportion was obtained by the usual three-stage equation:

$$\hat{V}[\bar{y}_{kh}] = \left[(1 - f_{1h}) \frac{s_{1kh}^2}{d_h^*} \right] + \left[\frac{f_{1h}}{d_h^{*2}} \sum_{i=1}^{d_h^*} [(1 - f_{2hi}) \frac{s_{2khi}^2}{p_{hi}^*}] \right]$$

$$+ \left[\frac{f_{1h}}{d_h^{*2}} \sum_{i=1}^{d_h^*} \frac{f_{2hi}}{p_{hi}^{*2}} \sum_{j=1}^{p_{hi}^*} \frac{s_{3khij}^2}{m_{hij}} \right] ; \quad \text{(A3.8)}$$

where: d_h^* equals the number of days sampled for interviews in each stratum in which at least one period sampled had interviews;

$$s_{1kh}^2 = \frac{\sum_{i=1}^{d_h^*} (\bar{y}_{khi} - \bar{\bar{y}}_{kh})^2}{d_h^* - 1} ; \quad \text{(A3.9)}$$

$$s_{2khi}^2 = \frac{\sum_{j=1}^{p_{hi}^*} (\bar{y}_{khij} - \bar{y}_{khi})^2}{p_{hi}^* - 1} ; \quad \text{(A3.10)}$$

$$s_{3khij}^2 = \frac{\sum_{o=1}^{m_{hij}} (y_{khijo} - \bar{y}_{khij})^2}{m_{hij} - 1} ; \text{ and} \quad \text{(A3.11)}$$

all other terms are as defined above.

-continued-

Once the estimated proportion and its variances were calculated for all strata in an iteration, the statistics were combined as weighted averages to estimate one set of statistics (p_k's) of harvest distribution for the entire fishery:

$\hat{p}_k$ = the estimated fraction of completed angler-trips in which anglers harvest 0 or at least k chinook salmon;

$$= \sum_{h=1}^{s} \hat{W}_h \equiv \bar{y}_{kh} \; ; \qquad \text{(A3.12)}$$

$\hat{V}[\hat{p}_k]$ = variance estimate, obtained by treating the stratum weights as constants, rather than as estimates, and as such obtained approximately by (see Kish 1965, equations 2.8.5 and 2.8.7, pages 60 and 61);

$$\approx \sum_{h=1}^{s} \hat{W}_h^2 \equiv \hat{V}[\bar{y}_{kh}] \; ; \qquad \text{(A3.13)}$$

where:

$\hat{W}_h$ = estimated relative stratum (equivalent to the ratio of the estimated number of angler-trips for each stratum compared to the total number of angler-trips for the fishery);

$$= \frac{\hat{M}_h}{\hat{M}} \; ; \qquad \text{(A3.14)}$$

$\hat{M}_h$ = estimated number of angler-trips for each stratum;

$$= D_h \bar{\hat{M}}_h \; ; \qquad \text{(A3.15)}$$

$\bar{\hat{M}}_h$ = unrestricted mean estimated number of angler-trips for each stratum;

$$= \frac{\sum_{i=1}^{d_h} \hat{M}_{hi}}{d_h} \; ; \qquad \text{(A3.16)}$$

-continued-

$\hat{M}_{hi}$ = unrestricted estimated number of angler-trips for each sampled day;

$$= P_{hi} \bar{\hat{M}}_{hi} \; ; \qquad \text{(A3.17)}$$

$\bar{\hat{M}}_{hi}$ = unrestricted mean estimated number of angler-trips for each sampled day;

$$= \frac{\sum_{j=1}^{p_{hi}} \hat{M}_{hij}}{p_{hi}} \; ; \qquad \text{(A3.18)}$$

$\hat{M}$ equals the total number of estimated angler-trips across all strata; and all other terms are as defined above.

Standard errors were obtained by taking the square root of the variance estimates.

Appendix A4. Estimation equations for the age composition in proportions and in numbers for the fish harvested in the chinook salmon sport fishery in Willow Creek and the escapement through the Deception Creek weir, 1991.

Proportions of each age class of fish harvested in each stratum of the sport fishery or the escapement through the weir were calculated according to the following procedures:

$\hat{p}_{uh}$ = estimated proportion of the sampled chinook salmon harvested that are age *u* within each stratum;

$$= \frac{n_{uh}}{n_h}; \qquad \text{(A4.1)}$$

where: n_{uh} equals the number of the sampled chinook salmon harvested within each stratum that are age *u*; and n_h equals the total number of chinook salmon sampled within each stratum.

The variance of the estimated proportion of chinook salmon harvested was estimated approximately by the standard equation for the variance of a binomial proportion (Cochran 1977, equation 3.8, page 52):

$$\hat{V}[\hat{p}_{uh}] \approx \left(1 - \frac{n_h}{\hat{H}_h}\right) \frac{\hat{p}_{uh}(1 - \hat{p}_{uh})}{n_h - 1} \text{ or } \left(1 - \frac{n_h}{N_h}\right) \frac{\hat{p}_{uh}(1 - \hat{p}_{uh})}{n_h - 1}; \qquad \text{(A4.2)}$$

where: $\hat{H}_h$ equals the estimated harvest of chinook salmon in each stratum, obtained from equation 37 of Bartlett and Bingham (1991); and N_h equals the number of chinook salmon counted past the weir during each weir stratum period.

Next we estimated weighted proportions for each age class across all stratum:

$$\hat{p}_u = \sum_{h=1}^{s} \hat{W}_h \hat{p}_{uh} \quad \text{or} \quad \sum_{h=1}^{s} W_h \hat{p}_{uh}; \qquad \text{(A4.3)}$$

where:

$$\hat{W}_h = \frac{\hat{H}_h}{\hat{H}} \quad \text{or} \quad W_h = \frac{N_h}{N}; \text{ and} \qquad \text{(A4.4)}$$

$\hat{H}$ equaled the total harvest or N equaled the total number of chinook salmon counted past the weir over all stratum.

-continued-

The variance of the estimated proportion of fish harvested which are age class u across all stratum was obtained by Goodman's (1960) equation for the variance of the product of two random variates:

$$\hat{V}[\hat{p}_u] = \sum_{h=1}^{s} \left\{ \hat{W}_h^2 \, \hat{V}[\hat{p}_{uh}] + \hat{p}_{uh}^2 \, \hat{V}[\hat{W}_h] - \hat{V}[\hat{p}_{uh}] \, \hat{V}[\hat{W}_h] \right\} ; \qquad (A4.5)$$

where:

$$\hat{V}[\hat{W}_h] = \left\{ \frac{\hat{H}_h}{\hat{H}} \right\}^2 \left\{ \frac{\hat{V}[\hat{H}_h]}{\hat{H}_h^2} + \frac{\hat{V}[\hat{H}]}{\hat{H}^2} - \frac{2 \, \hat{V}[\hat{H}_h]}{\hat{H}_h \, \hat{H}} \right\} . \qquad (A4.6)$$

The variance of the estimated proportion of fish past the weir which are age class u across all stratum was obtained by:

$$\hat{V}[\hat{p}_u] = \sum_{h=1}^{s} \left\{ W_h^2 \, \hat{V}[\hat{p}_{uh}] \right\} . \qquad (A4.7)$$

Appendix A5. Estimation equations for the hatchery contribution of stocked chinook salmon to the sport fishery in Willow Creek and the escapement through the Deception Creek weir, 1991.

Contributions of Coded Wire Tagged Stocks to the Harvest:

The first step of estimating the contribution to each sampling stratum (or combined strata as noted above) in the sport fishery of each particular tag code (using equation [10] from Clark and Bernard 1987):

$\hat{H}_{A_h}$ = estimated contribution of stocked fish from release associated with unique tag code *A* for fishery stratum *h*;

$$= \left\{ \frac{\hat{H}_h}{n_{2_h}} \right\} \left\{ \frac{a_{1_h}}{a_{2_h}} \right\} \left\{ \frac{m_{1_h}}{m_{2_h}} \right\} \left\{ \frac{m_{a_h}}{\theta_A} \right\} ; \qquad \text{(A5.1)}$$

where: $\hat{H}_h$ equals the estimated harvest of all chinook salmon within each stratum; n_{2_h} is the number of chinook salmon inspected for missing adipose fins from the sampled harvest in each fishery stratum; a_{1_h} equals the number of chinook salmon with a missing adipose fin which were counted and marked with a head strap from each stratum; a_{2_h} equals the number of chinook salmon heads previously marked with a head strap which arrived at the tag lab, from fish originally sampled from stratum *h*; m_{1_h} equals the number of coded wire tags which were detected in the chinook salmon heads at the tag lab, from those sampled from stratum *h*; m_{2_h} is the number of coded wire tags which were removed from the chinook salmon heads and decoded, from chinook salmon sampled from stratum *h*; m_{a_h} is the number of coded wire tags dissected out of the chinook salmon heads and decoded as the unique tag code *a*, originally sampled from stratum *h*; and θ_A equals the proportion of a particular hatchery release which contains a coded wire tag of the unique tag code *A*.

The variance of the above estimate was obtained following the approach proposed by Conrad and Larson (1987), in which the number of tags decoded as a unique tag code (*A*) and the total harvest estimate were treated as random variates, and all other terms in equation A5.1 were treated as constants (accordingly the approach first proposed by Goodman 1960 was used for the second major term in equation A5.2):

$$S^2_{\hat{H}_{A_h}} \approx \left\{ \frac{1}{n_{2_h}} \frac{a_{1_h}}{a_{2_h}} \frac{m_{1_h}}{m_{2_h}} \frac{1}{\theta_A} \right\}^2$$

$$\left\{ \hat{H}_h \, V[m_{A_h}] + m^2_{A_h} \, \hat{V}[\hat{H}_h] - V[m_{A_h}] \, \hat{V}[\hat{H}_h] \right\} ; \qquad \text{(A5.2)}$$

-continued-

where: $\hat{V}[\hat{H}_h]$ equals the estimated variance of overall chinook salmon harvest estimate for stratum *h*, obtained from creel survey sampling programs; and

$V[m_{A_h}]$ = variance of "random variate" m_{A_h}, approximated by the approach used by Clark and Bernard (1987; equation [12]);

$$\approx \frac{n_{2_h}(n_{2_h}-1)a_{2_h}(a_{2_h}-1)m_{2_h}(m_{2_h}-1)\hat{H}_{a_h}(\hat{H}_{a_h}-1)\theta_A^2}{\hat{H}_h(\hat{H}_h-1)a_{1_h}(a_{1_h}-1)m_{1_h}(m_{1_h}-1)}$$

$$+ \frac{n_{2_h}a_{2_h}m_{2_h}\hat{H}_{A_h}\theta_A}{\hat{H}_h a_{1_h} m_{1_h}}$$

$$- \left[\frac{n_{2_h}a_{2_h}m_{2_h}\hat{H}_{A_h}\theta_A}{\hat{H}_h a_{1_h} m_{1_h}} \right]^2 . \qquad \text{(A5.3)}$$

The final step in calculating the variance of the contribution estimate for each tag code was to perform the following bias correction (Clark and Bernard 1987; equation [15]):

$$\hat{V}[\hat{H}_{A_h}] = \left[\frac{(\hat{H}_h-1)n_{2_h}(a_{1_h}-1)a_{2_h}(m_{1_h}-1)m_{2_h}}{\hat{H}_h(n_{2_h}-1)a_{1_h}(a_{2_h}-1)m_{1_h}(m_{2_h}-1)} \right] S^2_{H_{A_h}} . \qquad \text{(A5.4)}$$

In order to obtain the estimated contribution to the fishery across combinations of different tag codes and/or different strata, the following equations were used (as outlined by Clark and Bernard 1987, equation [16]):

$\hat{H}_C$ = estimated total contribution of a combination of tag codes and sampling strata;

$$= \sum_{h=1}^{s} \sum_{A=1}^{t} \hat{H}_{A_h} \qquad \text{(A5.5)}$$

where: s equals the number of strata to be combined; and t is the number of tag codes to be combined.

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The variance of this combined estimate was obtained by (Clark and Bernard 1987, equation [17]):

$$\hat{V}[\hat{H}_C] = \left[\sum_{h=1}^{s} \sum_{A=1}^{t} \hat{V}[\hat{H}_{A_h}] \right] + \left[2 \sum_{h=1}^{s} \sum_{A=1}^{t} \sum_{B>A}^{t} \hat{cov}[\hat{H}_{A_h}, \hat{H}_{B_h}] \right] ; \quad (A5.6)$$

where:

$\hat{cov}[\hat{H}_{A_h}, \hat{H}_{B_h}]$=estimated covariance between the estimated contributions for unique tag code *A* and *B* within stratum *h* (note that we assume that sampling was conducted independently between strata, therefore covariances are only needed for the within stratum values), obtained as outlined by Clark and Bernard (1987, equation [22]);

$$= \hat{H}_{A_h} \hat{H}_{B_h} \left[\frac{\hat{H}_h (n_{2_h}-1) a_{1_h} (a_{2_h}-1) m_{1_h} (m_{2_h}-1)}{(\hat{H}_h-1) n_{2_h} (a_{1_h}-1) a_{2_h} (m_{1_h}-1) m_{2_h}} - 1 \right] . \quad (A5.7)$$

Relative Contributions of Coded Wire Tagged Stocks to the Escapement:

Since we did not have an absolute measure of the escapement, contributions in numbers (i.e., n_1 as noted above) could not be estimated for the escapement sampling program. Accordingly we estimated the relative contributions of various tag lots:

$$\hat{p}_{c_A} = \frac{\hat{p}_{m_A}}{\theta_A} ; \quad (A5.8)$$

where: θ_A is as defined above;

$\hat{p}_{m_A}$ = the estimated marked to unmarked ratio for each tag code of interest, obtained as;

$$= \frac{m_{c_A}}{n_2} ; \quad (A5.9)$$

where: m_{c_A} equals the number of tagged chinook salmon of a particular tag code sampled from the escapement; and n_2 equals the number of chinook salmon examined in the escapement sampling for the presence of CWT's.

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The variance of the relative contribution estimate is equal to:

$$\hat{V}[\hat{p}_{c_A}] = \frac{\hat{V}[\hat{p}_{m_A}]}{\theta_A^2} \qquad \text{(A5.10)}$$

where: the variance of p_m is the variance of a binomial, or:

$$\hat{V}[\hat{p}_{m_A}] = \left[\frac{\hat{p}_{m_A} (1 - \hat{p}_{m_A})}{n_2 - 1} \right] . \qquad \text{(A5.11)}$$

The above procedures (i.e., equations A5.8-A5.11) assume that there will be no (or minimal) head or tag loss (and no undecodable tags).

If these assumptions are not valid, then the procedures outlined in equations A5.1-A5.7 will be adapted[1] in order to obtain the relative contribution estimates, then the relative contribution of a tag code is equal to:

$$\hat{p}_{c_A} = \frac{\hat{n}_{1_A}}{n_2} \qquad \text{(A5.12)}$$

and the variance of the relative contribution estimate is equal to:

$$\hat{V}[\hat{p}_{c_A}] = \frac{\hat{V}[\hat{n}_{1_A}]}{n_2^2} \qquad \text{(A5.13)}$$

where: $\hat{n}_{1_A}$ is the estimated contribution of a particular tag code and

$\hat{V}[\hat{n}_{1_A}]$ is the variance of the estimate.

[1] By equating the estimated harvest to the unknown escapement abundance; moving the unknown abundance term to the left-hand-side [LHS] of equation 49, i.e., making the LHS the proportional contribution estimate; and assuming that the escapement is relatively large [i.e., N } N - 1].

APPENDIX B

Appendix B1. Numbers of chinook salmon smolt stocked into the Willow Creek drainage from 1985-1991 with corresponding release and recovery information.

Brood Year	Release Location	Total Smolt Release	Valid Number Coded Wire Tagged[a]	Mean Size	Release Date	Tag Code	Exp. Factor[b]	Total Tag Recoveries	Min. Est. Return[c]	Min. Est. Survival to Adult[d]	Last Return Year
1983	Deception	101,256	8,152	18.0	6/13/85	31-16-42	12.4	3	49	<0.05%	1989
1984	Deception	214,384	11,038	13.8	6/11-12/85	31-16-45	19.4	26	1,230	0.6%	1989
	Deception	218,743	10,708	14.0	6/20/85	31-16-47	20.4	29	911	0.4%	1989
1985	Deception	49,668	9,933	16.7	5/01/86	31-17-33[e]	5.0	5	60	0.1%	1990
	Deception	127,904	18,400	12.2	5/10/86	31-17-27					
	Deception	147,877		11.4	5/10/86						
		275,781	18,400				15.0	9	264	0.1%	1990
1987	Deception	201,091	20,936	10.9	7/12/88	31-17-58	9.6	85	1,856	0.9%	1992
1988	Deception	240,885	19,851	13.0	5/31/89	31-17-60	12.1	7	222	0.1%	1993
1989	Deception	219,362	41,570	14.4	5/24/90	31-17-34	5.3				1994
	Deception	219,432	40,575	13.4	5/24/90	31-18-51	5.4				1994
	Deception	216,697	40,438	13.9	5/24/90	31-18-52	5.4				1994
1990	Deception	168,777		11.2	5/21/91						
	Deception	70,258	31,167	12.3	5/31/91	31-19-33					
	Willow	73,756		12.3	5/28/91						
	Willow	78,878	31,167	12.3	5/30/91	31-19-33					
		391,669	62,334				4.6				1995

[a] Number of smolt released with adipose finclip and coded wire tag inserted in head.

[b] Total smolt release divided by number coded wire tagged.

[c] Minimum estimated return to Willow Creek includes estimated CWT recoveries from sport fishery harvest (creel survey), estimated escapement (carcass surveys), and Deception Creek egg take. No estimate is made for the interception in the commercial fishery (Copper River, Cook Inlet), nontarget sport fisheries (Homer, Susitna River) or straying from Willow Creek.

[d] Minimum estimated return (estimated from total CWT recoveries) divided by total smolt release times 100 percent.

[e] Coded wire tag release 31-17-33 are Deshka River chinook mistakenly released in Willow Creek.

Appendix B2. Numbers of chinook salmon smolt stocked into Montana and Sheep creeks in 1987 and 1988 with corresponding release information.

Brood Year	Tag Code	Number Tagged	Number Released	Expansion Factor	Proportion Tagged	Mean Size (g)	Lifestage	Release Date	Release Location	Dominant Return
1987	31-17-59	21,615	132,465	6.1	0.1632	10.9	smolt	7/05/88	Montana Creek	1992
1987	No tag		132,125		0.0000	10.9	smolt	7/07/88	Sheep Creek	1992
1988	31-17-31	20,391	177,789			12.3	smolt	6/07/89	Montana Creek	1993
	No tag		7,317			12.3	smolt	6/12/89	Montana Creek	
	Total	20,391	185,106	9.1	0.1102					
1988	31-17-36	20,263	181,252			12.3	smolt	6/06/89	Sheep Creek	1993
	No tag		26,927			12.3	smolt	6/12/89	Sheep Creek	
	Total	20,263	208,179	10.3	0.0973					

Appendix B3. Tag recoveries from chinook salmon stocked in Willow Creek and recovered in nontarget fisheries, 1986-1991.

Year	Tag Code	Recovery Date	Statistical Area	Name of the Fishery
1986		No Recoveries		
1987	31-16-47	11-Jul-87	331-	Kotzebue Sound Subsistence Fishery (Sheshalic)
1988		No Recoveries		
1989	31-17-27	14-Jul-89	157-	Southeast Troll Fishery Outside Waters
1990	31-17-58	11-Jun-90	247-	Cook Inlet Gill Net
1991	31-17-58	31-May-91	212-	Copper River Gill Net
	31-17-58	20-May-91	244-10	Homer Sport Fishery
	31-17-58	18-Jun-91	224-30	Crooked Creek Sport Fishery
	31-17-60	20-May-91	212-	Copper River Gill Net
	31-18-51	16-Jul-91	212-	Copper River Gill Net

Appendix B4. Coded wire tag recoveries of Willow Creek chinook salmon from 1986-1991 in the Deception Creek egg take, Willow Creek creel survey, and Willow Creek carcass surveys.

			1986	1987	1988		1989			1990			1991			
Brood Year	Tag Code	Expansion Factor	Deception Creek Egg take	Deception Creek Egg take	Deception Creek Egg take	Willow Creek Creel Survey[a]	Deception Creek Egg take	Willow Creek Carcass Survey	Willow Creek Creel Survey[a]	Deception Creek Escapement[b]	Willow Creek Carcass Survey	Willow Creek Creel Survey[a]	Deception Creek Escapement[b]	Willow Creek Carcass Survey	Willow Creek Creel Survey[a]	Total
1983	31-16-42	12.4	1	2												3
1984	31-16-45	19.4	2	6	1	2	3	1	10			1				26
	31-16-47	20.4	2	16	3	2			5			1				29
1985	31-17-33	5.0			1		1			2	1					5
	31-17-27	15.0					1		1	2		5				9
1987	31-17-58	9.6								22	1	33	10		19	85
1988	31-17-60	12.1								1		1			5	7
1989	31-17-34	5.3														0
	31-18-51	5.4														0
	31-18-52	5.4														0
1990	31-19-33	4.6														0
Total Tag Recoveries			5	24	5	4	5	1	16	27	2	41	10	0	24	164
Total Fish Examined			296	692	358	528	358	632	1,005	659	703	1,309	309	270	1,063	8,182

[a] Only chinook salmon greater than 16 inches are included.

[b] Deception Creek weir and Deception Creek carcass survey combined.

Appendix B5. Estimated number of hatchery produced Willow Creek chinook salmon in the Deception Creek egg take, Willow Creek carcass survey, and Willow Creek creel survey, 1986-1991.

			1986	1987	1988		1989			1990			1991			
Brood Year	Tag Code	Expansion Factor	Deception Creek Egg take	Deception Creek Egg take	Deception Creek Egg take	Willow Creek Creel Survey[a]	Deception Creek Egg take	Willow Creek Carcass Survey	Willow Creek Creel Survey[a]	Deception Creek Escapement[b]	Willow Creek Carcass Survey	Willow Creek Creel Survey[a]	Deception Creek Escapement[b]	Willow Creek Carcass Survey	Willow Creek Creel Survey[a]	Total
1983	31-16-42	12.4	21	28												49
1984	31-16-45	19.4	68	28	55	159	128	153	609			30				1230
	31-16-47	20.4	68	118	182	167			320			56				911
1985	31-17-33	5.0			16		16			11	17					60
	31-17-27	15.0					33		47	32		152				264
1987	31-17-58	9.6								224	32	767	232		601	1856
1988	31-17-60	12.1								13		23			186	222
1989	31-17-34	5.3														0
	31-18-51	5.4														0
	31-18-52	5.4														0
1990	31-19-33	4.6														0
Estimated Total Return			157	174	253	326	177	153	976	280	49	1,028	232	0	787	4,592

[a] Only chinook salmon greater than 16 inches are included.

[b] Deception Creek weir egg take and Deception Creek carcass survey combined.

Appendix B6. Estimated yearly age composition of Willow Creek chinook salmon from 1979-1991 based on sport fish harvests with a corresponding estimate of minimum run size.

Year[b]	Sample Size	Age Class by Percent[a] 1.2[c]	1.3[c]	1.4[c]	Sport Harvest	Escapement Indices	Estimated Minimum Run Size
1979	152	10.0	14.0	76.0	285	1,087	1,372
1980	120	29.0	18.0	53.0	292		292
1981	155	12.0	36.0	52.0	345	1,357	1,702
1982	308	7.0	18.0	75.0	390	821	1,211
1983	896	30.0	30.0	40.0	393	892	1,285
1984	1,113	13.0	40.0	47.0	805	3,464	4,269
1985	448	14.0	24.0	62.0	763	2,900	3,663
1986	143	15.0	38.0	46.0	1,043	2,580	3,623
1987	148	28.0	31.0	41.0	1,720	3,460	5,180
1988	344	16.0	49.0	35.0	2,160	3,286	5,446
1989	362	7.0	19.0	74.0	2,570	5,860	8,430
1990	413	32.0	17.0	51.0	2,789	3,065	5,854
1991	361	10.0	37.0	53.0	2,997	2,753	5,750
Mean		17.2	28.5	54.2			
Maximum		32.0	49.0	76.0			
Minimum		7.0	14.0	35.0			

[a] Other age classes exist (1.1, 1.5, 2.2, 2.3, 2.4, 2.5) but never make up more than 5% of the return on a combined basis.

[b] Source of data: 1979, Watsjold 1980; 1980, Watsjold 1981; 1981, Bentz 1982; 1982, Bentz 1983; 1983, Hepler and Bentz 1984; 1984, Hepler and Bentz 1985; 1985, Hepler and Bentz 1986; 1986, Hepler and Bentz 1987; 1987, Hepler et al. 1988; 1988, Hepler et al. 1989; 1989, Sweet and Webster 1990; 1990, Sweet et al. 1991.

[c] Although all hatchery produced chinook salmon are age 0 in fresh water, it is not detectable. The scales are read as age 1 in fresh water.

Appendix B7. Estimated mean lengths by age and sex from sport harvests of Willow Creek chinook salmon, 1986-1991.

	Age Class 1.2					Age Class 1.3					Age Class 1.4				
	Male		Female		Combined	Male		Female		Combined	Male		Female		Combined
Year[a]	Sample Size	Length (mm)	Sample Size	Length (mm)	Length (mm)	Sample Size	Length (mm)	Sample Size	Length (mm)	Length (mm)	Sample Size	Length (mm)	Sample Size	Length (mm)	Length (mm)
1986	22	642	0	0	642	22	841	33	861	853	17	1,027	49	955	974
1987	35	600	0	0	600	33	841	13	883	853	20	961	34	936	945
1988	61	619	6	690	625	133	822	95	836	828	70	975	116	939	953
1989	36	578	0	0	578	63	790	27	835	804	112	952	245	914	926
1990	173	575	0	0	575	61	801	23	871	820	88	983	135	934	953
1991	56	594	0	0	594	117	786	66	830	802	107	980	205	926	945
Mean		601	No estimate		602		814		853	827		980		934	949
Maximum		642			642		841		883	853		1,027		955	974
Minimum		575			575		786		830	802		952		914	926

[a] Source of data: 1986, Hepler and Bentz 1987; 1987, Hepler et al. 1988; 1988, Hepler et al. 1989; 1989, Sweet and Webster 1990; 1990, Sweet et al. 1991.

Appendix B8. Estimated sex composition by age class for sport harvests of Willow Creek chinook salmon for the period 1986-1991.

	Age Class 1.2				Age Class 1.3				Age Class 1.4			
	Male		Female		Male		Female		Male		Female	
Year[a]	Sample Size	Percent	Sample Size	Percent	Sample Size	Percent	Sample Size	Percent	Sample Size	Percent	Sample Size	Percent
1986	22	100.0	0	0.0	22	40.0	33	60.0	17	25.4	50	74.6
1987	37	88.1	5	11.9	35	76.1	11	23.9	22	36.7	38	63.3
1988	53	91.4	5	8.6	97	57.1	73	42.9	48	41.0	69	59.0
1989	27	100.0	0	0.0	47	70.1	20	29.9	85	31.7	183	68.3
1990	134	100.0	0	0.0	48	70.6	20	29.4	82	39.2	127	60.8
1991	35	100.0	0	0.0	83	61.5	52	38.5	60	31.4	131	68.6
Mean		96.6		3.4		62.6		37.4		34.2		65.8
Maximum		100.0		0.0		76.1		23.9		41.0		59.0
Minimum		88.1		11.9		40.0		60.0		25.4		74.6

[a] Source of data: 1986, Hepler and Bentz 1987; 1987, Hepler et al. 1988; 1988, Hepler et al. 1989; 1989, Sweet and Webster 1990; 1990, Sweet et al. 1991.

Appendix B9. Seasonal timing of sport harvest by percent for Willow Creek chinook salmon, 1986-1991.

1986[a]		1987[b]		1988[c]		1989[d]		1990[e]		Mean 86-90		1991	
Date	%	Date	%	Date	%	Date	%	Date	%	Date	%	Date	%
6/14-15	21					6/09-16	2	6/09-15	6	6/08-16	6	6/08-14	5
6/21-22	22	6/20-21	21	6/18-20	26	6/17-19	7	6/16-18	11	6/15-22	17	6/15-17	8
6/28-29	36	6/27-29	45	6/25-27	38	6/24-26	35	6/23-25	38	6/22-29	38	6/22-24	37
7/05-06	21	7/04-06	34	7/02-04	28	7/01-03	56	6/30-7/04	44	6/29-7/05	37	6/29-7/01	48
				7/09-11	8					7/05-7/11	2	7/06-07	2

[a] Hepler and Bentz 1987.

[b] Hepler et al. 1988.

[c] Hepler et al. 1989.

[d] Sweet and Webster 1990.

[e] Sweet et al. 1991.

APPENDIX C

Appendix C1. Estimates of the catch and harvest distribution of chinook salmon during the 1991 Willow Creek (mouth) creel survey.

Stratum	Estimated number of angler-trips	Parameter	Proportion of angler-trips that caught or harvested the noted number of chinook salmon: Caught[a]	SE	Harvested[b]	SE
1 (08 June - 14 June)	1,616	0 fish	0.868	0.090	0.893	0.087
		1 or more fish	0.132	0.033	0.107	0.028
		2 or more fish	0.018	0.008	0.000	0.000
		3 or more fish	0.011	0.007	0.000	0.000
		4 or more fish	0.007	0.005	0.000	0.000
		5 or more fish	0.000	0.000	0.000	0.000
		6 or more fish				
2 (15 June - 17 June)	1,266	0 fish	0.784	0.035	0.799	0.034
		1 or more fish	0.216	0.019	0.201	0.020
		2 or more fish	0.021	0.006	0.006	0.003
		3 or more fish	0.006	0.003	0.000	0.000
		4 or more fish	0.004	0.003	0.000	0.000
		5 or more fish	0.000	0.000	0.000	0.000
		6 or more fish	0.000	0.000	0.000	0.000
4 (22 June - 24 June)	2,893	0 fish	0.576	0.061	0.613	0.066
		1 or more fish	0.424	0.033	0.387	0.030
		2 or more fish	0.097	0.013	0.013	0.004
		3 or more fish	0.036	0.007	0.000	0.000
		4 or more fish	0.022	0.006	0.000	0.000
		5 or more fish	0.009	0.003	0.000	0.000
		6 or more fish	0.007	0.003	0.000	0.000
5 (29 June - 01 July)	3,003	0 fish	0.471	0.054	0.520	0.057
		1 or more fish	0.529	0.057	0.480	0.052
		2 or more fish	0.091	0.012	0.006	0.004
		3 or more fish	0.053	0.009	0.000	0.000
		4 or more fish	0.027	0.006	0.000	0.000
		5 or more fish	0.016	0.005	0.000	0.000
		6 or more fish	0.011	0.005	0.000	0.000
7 (06 July - 07 July)	1,817	0 fish	0.934	0.126	0.963	0.127
		1 or more fish	0.066	0.015	0.037	0.010
		2 or more fish	0.008	0.005	0.000	0.000
		3 or more fish	0.000	0.000	0.000	0.000
		4 or more fish	0.000	0.000	0.000	0.000
		5 or more fish	0.000	0.000	0.000	0.000
		6 or more fish	0.000	0.000	0.000	0.000
Season Total	10,595	0 fish	0.677	0.034	0.711	0.035
		1 or more fish	0.323	0.019	0.289	0.018
		2 or more fish	0.059	0.005	0.006	0.001
		3 or more fish	0.027	0.003	0.000	0.000
		4 or more fish	0.015	0.002	0.000	0.000
		5 or more fish	0.007	0.002	0.000	0.000
		6 or more fish	0.005	0.001	0.000	0.000

[a] Maximum observed catch equals 13.

[b] Maximum observed harvest equals 2.

Appendix C2. Number of chinook salmon inspected, number of adipose finclips observed, number of heads collected, and coded wire tag returns by strata from Willow Creek creel surveys in 1991.

	Strata							
Date	I 6/8-14	II 6/15-17	III[a] 6/18-21	IV 6/22-24	V 6/29-7/1	VI[a] 7/2-5	VII 7/6-7	Total
Mouth Survey								
# fish inspected	30	115	---	397	498	---	23	1,063
# clips observed	0	8	---	13	13	---	0	34
# heads collected	0	6	---	12	10	---	0	28
Coded wire tag number								
31-17-60[b]	0	1	---	3	1	---	0	5
31-17-59[c]	0	1	---	1	1	---	0	3
31-17-58[d]	0	3	---	8	8	---	0	19
No tag	0	1	---	0	0	---	0	1
Total CWT returns	0	6	---	12	10	---	0	28
Parks Highway Bridge Survey:								
# fish inspected	---	---	---	---	61	---	---	61
# clips observed	---	---	---	---	0	---	---	0
# heads collected	---	---	---	---	0	---	---	0
Mid River Survey:								
# fish inspected	---	---	---	7	20	---	---	27
# clips observed	---	---	---	0	0	---	---	0
# heads collected	---	---	---	0	0	---	---	0

[a] Fishery closed.

[b] Willow Creek 1989 release.

[c] Montana Creek 1988 release.

[d] Willow Creek 1988 release.

Appendix C3. Calculation of 1992 estimated return of chinook salmon to Willow Creek.

Historical Age Composition by Brood Year from Table 7

2 ocean	13.0%	
3 ocean	26.7%	
4 ocean	60.3%	

Estimated Returns from 1986 and 1987 Brood Years from Table 7

Brood Year	Origin	Estimated Return By Age Class 1.2	1.3	Total Return
1986	Wild	850	1,295	2,145
	Hatchery	1,023	833	1,856
	Total	1,873	2,128	4,001
1987	Wild	353		353
	Hatchery	222		222
	Total	575		575

Estimation of 4-ocean return in 1992:

The combined 2- and 3-ocean returns should compose 39.7% of the total return from the 1986 brood year.

If	2,145	=	39.7% of the wild return
Then	x	=	60.3%
Or	x	=	(60.3% x 2,145) / 39.7%
	x	=	3,258 wild 4-ocean return
If	1,856	=	39.7% of the hatchery return
Then	x	=	60.3%
Or	x	=	(60.3% x 1,856) / 39.7%
	x	=	2,819 hatchery 4-ocean return
Total 4-ocean return		=	3,258 + 2,819 wild + hatchery
		=	6,077 total

Estimation of 3-ocean return in 1992:

The 2-ocean return should compose 13.0% of the total return from the 1987 brood year.

If	353	=	13.0% of the wild return
Then	x	=	26.7%
Or	x	=	(26.7% x 353) / 13.0%
	x	=	725 wild 3-ocean return
If	222	=	13.0% of the hatchery return
Then	x	=	26.7%
Or	x	=	(26.7% x 222) / 13.0%
	x	=	456 hatchery 3-ocean return
Total 3-ocean return		=	725 + 456 wild + hatchery
		=	1,181 total

-continued-

Estimation of 2-ocean return in 1992:

Smolt release in 1990	655,491	
Estimated survival rate	3.0%	
Estimated percent 2 ocean	13.0%	
Predicted 2-ocean hatchery return	=	655,491 x 3.0% x 13.0%
	=	2,556
Predicted 2-ocean wild return	=	Historic mean 1975 to 1987
	=	512
Total 2-ocean return	=	2,556 + 512 wild + hatchery
	=	3,068 total

Total predicted return in 1992

	Wild	Hatchery	Total
4 ocean	3,258	2,819	6,077
3 ocean	725	456	1,181
2 ocean	512	2,556	3,068
Totals	4,495	5,831	10,326
Percent	43.5	56.5	100.0

APPENDIX D

Appendix D1. Computer data files and analysis programs developed for the chinook salmon stocking, creel survey, and escapement studies on Willow Creek, 1991.

Data Files

M004DS_1.DTA	Willow Creek, mouth, creel survey angler interview data file, 1991;
M004DC_1.DTA	Willow Creek, mouth, creel survey angler count data file, 1991;
M004PS_1.DTA	Willow Creek, mid river, creel survey angler interview data file, 1991;
M004PC_1.DTA	Willow Creek, mid river, creel survey angler count data file, 1991;
M004UCA1.DTA	Willow Creek, Parks Highway, creel survey angler interview data file, 1991;
M004BSU1.DTA	Willow Creek, Parks Highway, creel survey angler count data file, 1991;
M004DBA1.DTA	Willow Creek, mouth, creel survey biological data file, 1991;
M004PBA1.DTA	Willow Creek, mid river mouth and Parks Highway, creel survey biological data file, 1991;
M0040BA1.DTA	Willow Creek carcass survey biological data file, 1991;
M1290BA1.DTA	Deception Creek egg take biological data file, 1991;

Analysis Programs

UCSP91.EXE	RTS program to analyze raw data files from direct-expansion and roving creel surveys and generate estimates of angler effort, catch, and harvest;
BRA31WIL.RD	RTS report descriptive file for stage 1 of a stratified, three-stage, roving creel survey;
BRA32WIL.RD	RTS report descriptive file for stage 2 of a stratified, three-stage, roving creel survey;
BRA33WIL.RD	RTS report descriptive file for stage 3 of a stratified, three-stage, roving creel survey;
SFXTAB.EXE	RTS program used to cross-tabulate biological data files and produce either "discrete" or "continuous" tables of age, sex, length, and weight data;
MENU91.BAT	Series of RTS programs used to generate listing, frequency, and litho code reports from raw data;
WIL91CPU.SAS	SAS® System program used to estimate CPUE as index of abundance;
WIL91CHD.SAS	SAS® System program used to estimate distribution of angler catch and harvest;
AGEKS91.WK1	Lotus 1-2-3® worksheet used to weight and apportion chinook salmon harvest estimates by sex and age, within and across all stratum;

Data files are archived with the Alaska Department of Fish and Game, Division of Sport Fish, Research and Technical Services Unit, 333 Raspberry Road, Anchorage, Alaska 99518-1519. Contact Gail Heineman or Donna Buchholz (267-2369) for copies of the files and descriptions of the file format.